EVALUATION OF PATHWAYS FOR EXOTIC PLANT PEST MOVEMENT INTO AND WITHIN THE GREATER CARIBBEAN REGION

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Abbreviations and Definitions

Actionable pest	For the United States: a pest that triggers quarantine actions (*e.g.*, treatment, destruction or refusal of entry of commodity infested/infected with the pest) when intercepted at a port of entry.
Approach rate	The percentage of randomly inspected sampling units that contained what the search was targeting (*e.g.*, percentage of packages containing plant materials). The approach rate is usually given with a 95% binomial confidence limit (the limit within which the true approach rate falls with a 95% likelihood).
AQIM	Agricultural Quarantine Inspection Monitoring (randomized data collection at U.S. ports of entry)
APHIS	Animal and Plant Health Inspection Service (a branch of the USDA)
BTAG	Biological Threat Advisory Group. A Miami-based interdisciplinary pest risk discussion and analysis group
CARICOM	Caribbean Community and Common Market
CBP	Customs and Border Protection (a branch of the U.S. Department of Homeland Security, responsible for port-of-entry inspections)
CISWG	Caribbean Invasive Species Working Group
CRAG	Caribbean Risk Assessment Group. A Puerto Rico-based interdisciplinary pest risk discussion and analysis group
CRISIS	Caribbean Regional Invasive Species Intervention Strategy
CSI	Caribbean Safeguarding Initiative of United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine
DHS	U.S. Department of Homeland Security
Exotic pest	A pest not native to an area
GCR	Greater Caribbean Region: comprised of all countries bordering the Caribbean Sea, plus the Bahamas, Turks and Caicos, El Salvador, Suriname, Guyana, and the U.S. Gulf States. Note: The pest risk *to* Mexico, Venezuela, and Colombia is not addressed in this report.
IPPC	International Plant Protection Convention
ISPM	International Standard of Phytosanitary Measure
Pest	Any species of terrestrial arthropod, mollusk, weed, nematode, or plant pathogen that is injurious to plants or plant products
PPQ	Plant Protection and Quarantine (a branch of APHIS)
QM	Quarantine material
Reportable pest	For the United States: a pest that must be reported in the PestID database if intercepted at port of entry because it belongs to a taxonomic group whose members feed on plants. Not all reportable pests are actionable.
Safeguarding	All activities aimed at preventing the entry of exotic species into a country. Components of a safeguarding system may be: international risk management, port-of-entry exclusion measures, permitting systems and legal framework, domestic surveillance, and rapid response.
TEU	Twenty-foot equivalent unit (a unit of measurement for cargo containers)
USDA	United States Department of Agriculture
WADS	Work Accomplishment Data System
WPM	Wood packaging material

The Greater Caribbean Region (Image source: http://www.lib.utexas.edu/maps/americas/camericacaribbean.jpg)

Executive Summary

This report is the result of a collaboration between the Caribbean Invasive Species Working Group (CISWG) and the United States Department of Agriculture, Plant Protection and Quarantine (USDA-PPQ). The objective of this report is to contribute to an improved understanding of pathways of plant pest movement into and within the entire Greater Caribbean Region (GCR), thereby helping CISWG to enhance its Caribbean Regional Invasive Species Intervention Strategy (CRISIS) for preventing the introduction and spread of exotic pests.

The scope of this report includes all terrestrial, non-vertebrate plant pests, such as insects, mites, plant pathogens, nematodes, mollusks, and weeds. For the purposes of this report, the Greater Caribbean Region is defined as all countries bordering the Caribbean Sea, plus the Bahamas, Turks and Caicos, El Salvador, Suriname, Guyana, and the U.S. Gulf States (Florida, Alabama, Mississippi, Lousiana, and Texas). The pest risk *to* Mexico, Venezuela, and Colombia is not addressed in this report, though these countries are considered as sources of pest risk.

The pathways discussed are: human movement, airline passenger baggage, international mail, maritime traffic, hitchhikers, wood packaging material, forestry, propagative materials, and natural spread. The relative importance of each pathway was rated based on the available data, and recommendations for improved safeguarding are provided.

The pest risk associated with human movement, hitchhikers, wood packaging materials, forestry, and propagative materials was rated as very high. The pest risk associated with airline passenger baggage, mail, and natural pest spread was rated as medium. None of the pathways assessed was rated as low-risk. (See page 11 for a summary table of risk ratings.) Even though the pathways are discussed separately, there is considerable overlap between them. This must be taken into account in the development of mitigation measures.

Numerous specific recommendations for improved safeguarding are listed in this report. The main focus for improvements should be:

- Regional coordination, planning, and communication
- Education and involvement of the public
- Early warning, biosurveillance, and pest information systems
- Preparedness and rapid response

Chapter Summaries

Chapter 1: Human Movement

Evidence exists in the scientific literature and in government data that people moving between areas may contribute to the spread of plant pests in several different ways: by carrying the pest on themselves, their clothing, or their shoes; by transporting the pest on objects brought to or taken from an area (*e.g.*, handicrafts made from plant parts), or by intentionally collecting the pest to take it to a different location. The Greater Caribbean Region (GCR) is the most heavily-toured region in the world (Padilla and McElroy, 2005) – airline passengers exceed 30 million per year (UNWTO, 2008). Thus, the GCR is exposed to the risk of pest spread mediated by the movement of people.

Visitors to the GCR arrive by either air, water, or land, with air travel being the predominant mode of transportation (UNWTO, 2006). Once in the GCR, it is not uncommon for visitors to move between countries ("island-hop"), which is accomplished by regional flight, small boat, ferry, or – in most cases - cruise ship (Garraway, 2006). Frequenting several climatically similar destinations within a short time, cruise passengers may spread viable pests to new habitats within the GCR, especially with the current trends of ecotourism and private island experience leading to visitation of more natural and pristine areas. Cruise ship passengers are also likely to visit local markets, where they may buy handicrafts or other items that could harbor plant pests. Cruise ship, ferry, and small boat passengers are often not subject to phytosanitary inspections. Inspection of airline passenger luggage is common (see Chapter 2), but cannot do justice to the ever-increasing passenger volume.

Also of concern is the immense number of yachts and other small vessels moving around the Caribbean Sea, commonly entering countries without being subject to inspection. These vessels may be easily used to move quarantine materials (*e.g.*, agricultural cargo, plants for planting, souvenirs made of plant parts) between countries and may thus play an important role in facilitating the spread of pests.

The Central and South American nations of the GCR each share land borders with at least two other countries. These borders often can be crossed without agricultural inspection. Migrant farm workers cross some of the land borders in large numbers and may facilitate the regional spread of plant pests into agricultural areas. Local merchants and commuters also move back and forth between adjacent countries on a regular basis.

The obvious potential of humans to facilitate pest spread, together with the immense number of travelers into and within the GCR, and an overall insufficient level of phytosanitary safeguards warrant the pest risk associated with this pathway to be rated as **very high**.

Chapter 2: Airline Passenger Baggage

The large majority of all visitors to the Greater Caribbean Region (GCR) arrive by air (UNWTO, 2006). Because passenger baggage may contain pests (*e.g.*, snails, weed seeds) or items (*e.g.*, fruits or vegetables) that are infested with pests, international air travel has long been considered a pathway for the movement of pest organisms. This study quantifies the pest risk associated with airline passenger baggage, based on United States Department of Agriculture (USDA) and Department of Homeland Security (DHS) data and explores how this data may be applicable to other countries of the GCR.

The plant quarantine material (QM) approach rate is the percentage of passenger groups arriving at the border with plant QMs in their luggage. We calculated an overall plant QM approach rate of 3.75% (95% binomial confidence interval: 3.70-3.81%) for travelers to the United States and estimated that there were some 1.7 million arrivals of plant QM to the United States during 2006. We also estimated that only one quarter of these plant QMs were intercepted by phytosanitary inspections, leaving about 1.3 million plant QMs entering the United States undetected.

The plant QM approach rate is not the same as the pest approach rate, because not all QMs are infested with pests. We estimated that some 375,000 pest arrivals to the United States may have escaped detection by phytosanitary inspection in 2006.

Plant QM approach rates were significantly different between travel reasons. The category "Visit Family" was associated with the highest QM approach rates, followed by "Visit Friends". "Tourists" had considerably lower approach rates than both of the preceding categories.

The ten most commonly intercepted QMs were (in decreasing order of interception frequency): apples, mangoes, oranges, bananas, seeds, pears, unspecified fresh fruit, plums, yams, and plants. High-risk QMs intercepted included seeds, plants, and bulbs.

Out of the 25 countries of origin with the highest plant QM approach rates, ten were GCR countries: Haiti (approach rate: 21%), Bonaire (18%), St. Vincent (13%), Grenada (13%), Guadeloupe (12%), St. Lucia (11%), Antigua (9%), Bahamas (9%), Jamaica (8%), and Dominica (8%).

Even though the data was collected at U.S. ports of entry, it has applicability to other countries in the GCR, given that they receive visitors from many of the same countries of origin. Most travelers into the GCR countries are tourists, representing a comparatively low pest risk. Most visitors to the GCR come from Canada, France, Germany, and the United Kingdom (The Royal Geographical Society, 2004). The plant QM approach rates associated with these countries of origin were 8%, 4%, 5%, and 4%, respectively. The QMs intercepted from these countries were largely apples, bananas, and oranges. We estimated that over 1 million plant QMs arrivals associated with airline passenger baggage may occur in the GCR annually; however, because most visitors to the GCR are tourists from cooler-climate countries, and because the majority of QMs found on this type of traveler were fruits for consumption, we rated the risk associated with passenger baggage as **medium**.

Chapter 3: International Mail

Public and private postal services are an often overlooked pathway through which plants and plant pests may move into and within the Greater Caribbean Region (GCR). Using data on international mail entering the United States, we summarized the types of plant quarantine materials (QM) and plant pests detected in both private and public mail and calculated the corresponding QM approach rates.

Particularly common categories of high-risk items found in mail were: seeds, pods and other propagative plant materials, soil, wood, and wood items. Propagative materials represented about one third of the intercepted materials. Fresh fruits, vegetables, and other fresh plant parts, presenting a lower pest risk than propagative materials, were also detected.

More international mail is sent to the United States through the public postal service than through private mail. In other countries in the GCR, however, private postal services dominate the parcel market.

Of packages sent to the United States by private mail from world-wide and GCR origins, 0.13% and 1.6%, respectively, contained plant QMs. Of packages sent by public mail, 1.1% from world-wide and 0.8% from GCR origins contained plant QMs.

We estimated that the GCR (excluding the United States) may annually receive between 13,876 and 14,943 mail packages containing plant materials or plant pests, with up to 4,000 of these being propagative materials. International mail may be the pathway of choice for intentional smuggling of high-risk items. We rated the pest risk associated with the mail pathway as **medium**.

Chapter 4: Maritime Traffic

In the context of maritime traffic, there are several ways in which pests may be spread: with commodities (both agricultural and non-agricultural); as hitchhikers on the vessels and containers used for transport; and in the wood packaging material accompanying the commodities.

The pest risk associated with both hitchhikers and wood packaging material is discussed in detail in other chapters of this report. The pest risk associated with commodities, while very possibly the most important threat, is difficult to characterize due to the immense number of different commodities arriving from all over the world, each having a different level of pest risk associated with it. Given that legally traded commodities already receive attention from importing countries, and given that a general process for commodity pest risk assessment is in place (IPPC, 2007) and must be commodity- and origin-specific to be meaningful, this chapter does not focus on commodities.

Rather, this chapter gives a general overview of maritime traffic in the Greater Caribbean Region (GCR), pointing out some issues of special concern and providing a general background to complement the information laid out in other chapters of this report. Specifically, it compares Caribbean ports with regard to cargo container volume handled and discusses small vessel activity for select countries.

The GCR serves as a crossroads for international maritime trade. The region's location at the intersection of maritime trade routes between North and South America and the Eastern and Western hemispheres makes it an important area for facilitating trade.

Maritime traffic has been increasing in the GCR, and this trend is expected to continue. The United States is a primary trading partner in the GCR, providing almost half of all container traffic. However, trade with other countries, including those in Asia and Europe, has recently expanded. At several ports, the establishment of transshipment services accounts for much of the increase in sea container traffic. It is possible that transshipped containers can facilitate the introduction of exotic pests, as pests have been known to contaminate the exterior and/or interior of shipping containers (Gadgil *et al.*, 2000, Gadgil *et al.*, 2002).

Intra-Caribbean trade involves the movement of cargo within the GCR, either of products made in the GCR or foreign products being transshipped from one Caribbean port to another. Tracking of intra-Caribbean trade is difficult, with the level of regulation and record-keeping varying greatly between countries. Boerne (1999) estimated the number of small ships (less than 150 gross tonnage (GRT)) operating throughout the insular Caribbean to be around 200; and the United Nations estimated that around 400 to 500 small vessels (including vessels larger than 150 GRT) operated throughout the GCR (Boerne, 1999).

Chapter 5: Hitchhiker Pests

A hitchhiker pest is a plant pest that is moved, not on a host commodity, but either with a non-host commodity directly or on/in the conveyance (airplane, maritime vessel, *etc.*) or shipping container used for transport. This chapter examines the scientific literature and U.S. government data to assess the likelihood that hitchhiker pests are present on a conveyance, the likelihood that they survive transit, and the likelihood that they escape detection.

Hitchhiker pests may get into or onto a non-host commodity, conveyance, or container either by chance (*e.g.*, weed seeds that fall off shoes) or because they are attracted by certain physical or chemical conditions. For example, flying insects may be attracted by lights during nighttime loading (Caton, 2003b, Fowler *et al.*, 2008) or insects or mollusks may find shelter on or in cargo containers. Furthermore, pests that were originally associated with a host commodity shipment may be left behind in a container or conveyance after unloading, thus becoming hitchhiker pests.

In the scientific literature, there are numerous accounts of pests being associated with cargo containers or with the conveyance itself. In addition, hitchhiker pests are intercepted at U.S. ports of entry on containers, aircraft, and maritime vessels. Based on a 23% approach rate estimated by Gadgil *et al.* (2000), 1.6 million of the 7 million containers arriving annually at maritime ports in the GCR may be contaminated with one or more plant pests. Locations in the GCR that may receive more than 90,000 contaminated containers annually are: the Bahamas, Costa Rica, Jamaica, Netherlands Antilles, Panama, Puerto Rico, and the U.S. Gulf Coast states.

Pest survival in or on conveyances and containers depends on the combined effects of various environmental conditions and the duration of transport. Most insects, mollusks, weed seeds, and plant pathogens are likely to survive modern transit conditions and are very likely to escape detection. Several reports in the scientific literature strongly suggest that pests, such as Asian gypsy moth, *Lymantria dispar* (Lepidoptera: Lymantriidae), red imported fire ant, *Solenopsis invicta* (Hymenoptera: Formicidae), or terrestrial mollusks (Cowie and Robinson, 2003), have been introduced into new areas as hitchhiker pests.

A controlled study by Dobbs and Brodel (2004) carried out in 1998-1999 resulted in an estimate of 10% of all foreign cargo aircraft and 23% of cargo aircraft from Central American countries arriving in MIA with live plant pests of quarantine significance.

Routine quarantine inspections are likely to miss a large portion of the arriving pests. Factors impeding pest detection include: the level of available staff and resources compared to the immense number of incoming conveyances and containers, the limited amount of time available for inspection, and the large size and complex shape of conveyances.

Given the large number of conveyances and containers continuously circulating throughout the GCR and the numerous impediments to intercepting hitchhiker pests, the hitchhiker pathway should be considered a **very high** risk.

Chapter 6: Wood Packaging Material

Wood packaging material (WPM), used worldwide in shipments of both agricultural and non-agricultural products, is believed to have been the pathway for several pest introductions worldwide, including the pine wood nematode, *Bursaphelenchus xylophilus* (Tylenchida: Aphelenchoididae), in Portugal and the Asian longhorned beetle, *Anoplophora glabripennis* (Coleoptera: Cerambycidae), in the United States (New York and Illinois). In this study, we use U.S. government data to evaluate the potential role of WPM in the introduction of exotic pests into the GCR.

WPM is usually produced from low-grade wood of various tree species, often with bark and portions of the vascular cambium remaining (Clarke *et al.*, 2001). Damaged or otherwise unusable pallets are disassembled for the wood parts, which are then re-used to build or repair pallets (Bush *et al.*, 2002). Because WPM is routinely re-used and re-conditioned, the origin of the WPM is not necessarily the same as the origin of the commodity with which it is being imported.

To reduce the pest risk associated with WPM worldwide, the International Plant Protection Convention (IPPC) developed ISPM #15 (IPPC, 2006), an international standard which prescribes either fumigation or heat treatment for all WPM. Only a few countries of the GCR require treatment of WPM in accordance with ISPM #15 (Foreign Agricultural Service, 2008).

These countries are: Colombia, Costa Rica, Cuba, Dominican Republic, Guyana, Guatemala, Honduras, Nicaragua, and the United States.

U.S. data on maritime and air cargo, collected between September 16, 2005 (start date for U.S. enforcement of ISPM #15) and August 15, 2007, showed that 75% of maritime cargo shipments (agricultural and non-agricultural combined) contained WPM. Several countries in the GCR (Costa Rica, Guatemala, and the Dominican Republic) had high percentages of export cargo with WPM. New Zealand and several European countries had a high incidence of WPM in export cargo, while shipments from China had the lowest incidence of WPM. For air cargo, WPM was found in only 33% of shipments, with shipments from the Netherlands having by far the highest incidence of WPM.

Live pests are entering with WPM in spite of full enforcement of ISPM #15, as demonstrated by interceptions at U.S. ports of entry of wood-boring beetles of the families Curculionidae (Scolytinae) and Cerambycidae, as well as a variety of other insect orders, weeds, and mollusks. The presence of these pests in or on the WPM may be due to any one of the following reasons: ineffectiveness of the required treatments, incorrectly applied treatments, re-infestation of the wood after effective treatment, or fraudulent use of the stamp/seal. The majority of pests associated with WPM are likely to go undetected due to the large amount of WPM entering, the difficulty of inspecting WPM, and the fact that port-of-entry inspections of WPM often are limited to a verification of the required seal, rather than a search for pests.

Numerous pests intercepted on or in WPM have already established in the GCR, but many still have potential to spread further within the region. This chapter provides a list of WPM pests with establishment potential in the GCR. Each new establishment of these or similar pests anywhere in the world can increase the opportunities for further infestation of WPM and pest entry into the GCR.

Due to the immense quantity of WPM moving in international trade, the impossibility of determining the origin of the wood, and the difficulty of WPM inspections, we rated the pest risk associated with this pathway as **very high**.

Chapter 7: Forestry-related Pathways

Trade of forest products is a vital industry for several countries in the Greater Caribbean Region (GCR). The forests of the GCR, encompassing over 92 million hectares of land, have immense ecological, economic, and social importance. The susceptibility of these forests to exotic pest invasions is being increased through the effects of logging and other human activities.

Forests are at risk not only from pests introduced on forest products, but also from pests entering with agricultural commodities or through other pathways. At the same time, pests originating in forest areas may represent a threat not only to forests, but also to fruit plantations or agricultural production.

Important pathways for the introduction and movement of exotic plant pests related to forestry include wood products, non-wood forest products, and trees for planting (*e.g.*, for reforestation or in agroforestry systems).

Non-wood forest products include food products (*e.g.*, nuts, berries, leaves, and edible fungi), medicinals, bamboo, and craft products. Christmas trees have been a vehicle for the introduction of exotic pests into the GCR, and dried bamboo has served as a pathway for insect pests from China. Some of the trees introduced for use in commercial plantations become invasive species (Richardson, 1998). An extensive list of pests associated with forestry products which have the potential to move into and within the GCR is provided.

Due to the large number of pests associated with forest products, the fact that many of the most serious invasive pests around the world are forest pests, and the difficulty of mitigating pest risk on wood products we rated this pathway as **very high** risk.

Chapter 8: Plant Propagative Material

Plant propagative material, also referred to as nursery stock, is any plant material capable of and intended for propagation, including plants for planting.

As a pathway, propagative material overlaps with the other pathways discussed in this report in that propagative material may be transported by any of the available methods: airplane, cargo vessel, small boat, truck, public or private mail, as well as in the baggage of ship, plane or bus passengers, or in personal vehicles.

Reasons for importing propagative material include its use in commercial nursery and horticulture production, uses in agriculture and forestry, “plant exploration” by botanical gardens or researchers, or planting (*e.g.*, as ornamentals or food plants) by private collectors or homeowners.

The trade of propagative material is a multi-billion dollar industry. The United States, together with Canada, Israel, and the Netherlands, are the major exporters of nursery products to the Greater Caribbean Region (GCR) (UNComtrade, 2008).

Traded propagative material may present a phytosanitary risk in two ways: 1) by introducing exotic plant pests, and 2) by becoming an invasive weed in the introduced range.

Based on the available information, it is obvious that pests, and especially plant pathogens, are being spread between countries through both legal and illegal movement of propagative materials. This is occurring on a global scale. Due to the relative ineffectiveness of inspection and the unavailability of diagnostic tests for pathogens, there is no easy solution to this problem.

The propagative material pathway also allows invasive plants to enter the GCR, where they often cause considerable economic and environmental damage. The large majority of invasive exotic plant species in the GCR were introduced on purpose. There are almost no safeguards in place to prevent this from happening, as none of the countries in the GCR requires weed risk assessments as a condition for importation of propagative materials.

The propagative material pathway presents major safeguarding challenges, and the pest risk associated with this pathway should be considered **very high**.

Chapter 9: Natural Spread

Given the close proximity of land masses in the Greater Caribbean Region (GCR), natural spread of plant pests is a pathway for pest introduction. This chapter provides a review of the scientific literature to answer the following questions: 1) Does natural spread of pests occur into and within the GCR? 2) What are the prevailing spatial and temporal patterns of natural spread? 3) What types of pests are most prone to disperse by natural spread?

A substantial level of wind-assisted dispersion and migration of plant pests between the various islands and continents in the GCR is occurring on an on-going basis. Meteorological mechanisms operate throughout the GCR to accomplish such movement, and many plant pathogens, plants, and arthropods possess biological mechanisms for wind dispersal.

The Windward Islands form a gateway into the GCR. This is where the predominantly westward-bound winds first hit land after traveling across the Atlantic Ocean (Richardson and Nemeth, 1991). Some significant plant pathogens have been carried on the wind from Africa into the GCR (Purdy *et al.*, 1985), and swarms of locusts reached the Windward Islands from Africa on at least one occasion (Richardson and Nemeth, 1991). The prevailing winds tend to carry pests from the Windward Islands (the most southeasterly islands) to the Leeward Islands, the Greater Antilles and on to the southeastern United States.

The months of June, July, and August are the most likely time for the movement of pests out of the GCR and into the southeastern United States. Summer is the rainy season in many areas of the GCR, resulting in higher plant pest densities. While the prevailing winds are favorable for pest movement nearly year-round, tropical storms and hurricanes are more common in the summer and early fall (Rogozinski, 1999) and could contribute to the spread of plants pests.

Hurricanes have played a role in the spread of the Asian citrus canker bacterium *Xanthomonas axonopodis* pv. c*itri* (Xanthomonadales) (Irey *et al.*, 2006) and bean golden mosaic virus (BGMV) in the GCR. Although hurricanes can be a factor in the dispersal of some insect groups (Torres, 1992), the force of the storm would likely kill or injure most insects that are swept up. Tropical storms with less intense wind strength may be a more likely mechanism for natural movement of plant pests.

We rated the pest risk associated with this pathway as **medium**.

Summary of Risk Ratings by Pathway

	Pathway	Risk Rating		Comments
1	Human movement	very high	*****	Overlap with 2, 5, and 8
2	Airline passenger baggage	medium	***	Overlap with 1 and 8
3	Mail	medium	***	Overlap with 5 and 8
4	Maritime trade	*(no rating)*	*(no rating)*	Overlap with 5, 6, 7, and 8
5	Hitchhikers	very high	*****	Overlap with 1, 3, 4, 6, 7, and 8
6	Wood packaging material	very high	*****	Overlap with 4,5,7, and 8
7	Forestry-related pathways	very high	*****	Overlap with 5, 6, and 8
8	Propagative materials	very high	*****	Overlap with 1, 2, 3, 4, 5, 6, and 7
9	Natural spread	medium	***	

Pathways of Pest Movement Not Addressed in this Analysis

Due to time constraints, we were not able to analyze every potential pathway of pest movement in the GCR, but had to focus on those that seemed most significant and feasible. The following is a list of pathways which were not addressed in this report, but which may nevertheless represent a significant risk. These pathways may be explored in follow-up studies as resources become available.

- **Cut flowers entering Miami from the Caribbean.** This pathway was addressed to some degree in a series of CPHST documents in 2003-2005 (Caton, 2003c, d, e, a). Interesting questions in connection with this pathway include: the risk posed by the garbage and residue left over after cut flower inspection; the risk of flying insects escaping during inspection; the effectiveness of cut flower inspection.

- **Air cargo.** Most agricultural cargo in the GCR is transported by ship. Air transport seems to be mainly used for very high-value or highly persishable commodities (*e.g.*, green mangoes, strawberries, propagative materials, cut flowers, *etc.*) and for mail. For cut flowers, see above. Propagative materials and mail, as well as hitchhikers are covered in their own chapters.

- **Garbage.** Garbage arrives in connection with every type of transportation existing in the GCR. Airplanes, cruise ships, cargo vessels, buses, ferries, yachts, *etc.* There are numerous examples of animal pest and disease outbreaks around the world due to the mishandling of garbage (Benoit, 2008). The risks may be similar for plant pests.

- **Live animals as a pathway for weed seeds.** Weed seeds can be attached to the fur or wool and can also be found in the digestive tract of live animals. Research found that sheep are long-distance seed-dispersal vectors for seeds of any morphology, while cattle and deer dispersed hooked or bristly seeds over long distances, but not smooth seeds (Mouissie *et al.*, 2005). Also, feed, bedding material, and cages moved in connection with live animal trade can harbor weed seeds or other plant pests. Quarantine regulations for live animals vary among countries of the GCR, and modern quarantine facilities are not always available.

- **Military.** The movement of military equipment (ships, planes, tanks, cars, *etc.*) has been suspected as the cause of pest introductions in other parts of the world. Its significance for the spread of pest around the GCR is unknown.

- **Medicinal plants harvested from forests.** Trade in medicinal plants is increasing and includes whole plants, or parts such as bark, roots, stems, and leaves. Much of the plant material is harvested from forest areas. Inofficial trade within the GCR is probably common.

- **Bonsai trees.** A number of important pests have been intercepted on bonsai trees from China, among them *Scirtothrips dorsalis* (Thysanoptera: Thripidae), *Aleurocanthus spiniferus* (Hemiptera: Aleyrodidae), and larvae of Cerambicidae (Brodel, 2003). Bonsai trees from Asia may be a major pathway for host-associated pests (Brodel, 2003).

Recommendations for Improved Safeguarding

The recommendations with the highest expected cost-benefit ratio are preceded by a ❖.

General recommendations (not pathway-specific)

❖ **Create a regional, action-oriented group ("regional action group") to coordinate and carry out region-wide exotic species efforts.** This group may either be a strengthened and more strongly supported CISWG or a new entity, such as the National Plant Health Directors' group. All countries of the GCR, as well as not-for-profit organizations and universities should actively participate in this group. Governments should support this group by making available staff and other resources for projects and committees. The role of this group should be to plan regional projects, obtain funding and staffing, and oversee execution. Good project management practices should be employed. Coordination with other groups working in the same area should be a priority.

❖ **Carry out a region-wide public awareness campaign on invasive species, coordinated through the regional action group.** Educating the public on the potential consequences of exotic pest introductions and on ways to prevent them will increase people's willingness to comply with the rules and will make it easier for them to do so. Raised awareness will also make it more likely that exotic pest incursions are detected and reported by members of the public, and it will help recruit volunteers for exotic species prevention.

- Campaign should be region-wide with a consistent message.
- Effectiveness of materials should be evaluated by communication experts.
- Use a variety of media (*e.g.*, brochures, videos, pens, postcards, websites, *etc.*)
- Distribute message through: local television and radio; videos at airports, in airplanes, on cruise ships, *etc.*; travel agencies; schools and universities; volunteer lecturers; tourist markets; post offices; and e-mail.
- Measure impact through surveys (*e.g.*, of travelers at airports, cruise passengers, regular people in the street).
- Consider using the public awareness campaign developed by Australia (Plant Health Australia, 2008) as a starting point.
- Develop curricula on invasive species to be used in elementary school through university.

❖ **Develop a web-based clearinghouse of information related to exotic species in the GCR.** For the effective coordination of regional acitivities information-sharing is absolutely essential. Develop a web-portal containing, among other things: a listing of organizations and groups active in exotic species management in the GCR, relevant reports and publications, links to electronic journals of relevant content, listing of relevant meetings and events, meeting minutes and proceedings, educational materials for downloading (*e.g.*, slide presentations with audio), codes of conduct, and access to databases of relevant content. The Jamaica Clearing-House Mechanism, Jamaica's Biodiversity Information Network (htpp://www.jamaica.org.jm), may serve as an example. The development and maintenance of the portal should be coordinated through the regional action group. The portal should be complementary to and integrated with the International Phytosanitary Portal (https://www.ippc.int/IPP/En/default.jsp).

- **Develop surveillance systems for the early detection of pests.** By itself, port-of-entry inspection is not and can never be an effective safeguarding method. In the GCR, natural spread of pests may be inevitable. Early detection is key in responding to new pest introductions.
  - Surveillance programs for the early detection of exotic species should be implemented. This is one of the goals of the CISWG Caribbean Invasive Species and Surveillance Program (CISSIP), for which a detailed project proposal has been developed but funding has not yet been obtained. Depending on the likelihood that funding can be found, the CISSIP project plan may have to be reconsidered in order to move forward.
  - Decisions will need to be made regarding which pests to survey for and which areas to survey. The USDA Cooperative Agricultural Pest Survey (CAPS) Program has developed a process for making this kind of decisions using the analytical hierarchy process. A Central America Pest Survey Program (CAPS-CA) has been suggested for Honduras, Nicaragua, Costa Rica, and Panama.
  - Involve the public in surveillance and diagnostics. Hobby entomologists and botanists, gardeners, nursery professionals, *etc.*, may be important and competent contributors to a regional surveillance system. Some examples of initiatives that collect distribution information through amateur biologists are: bugguide.net and zipcodezoo.com.

- **Develop an effective integrated biosurveillance and pest information system for the entire GCR, also to be used as a mechanism for official pest reporting.** Both safeguarding against and responding to pest introductions depends strongly on current pest information. Of special importance is information on distribution, host range, trapping and identification tools, control methods, and port interception records. The sheer amount of pest information available throughout the world and the fast pace at which new information appears make it impossible for any individual to stay abreast of it. The collection, analysis, dissemination, and storage of pest information must occur in an efficient and organized manner. It would be most cost effectively done on a GCR-wide basis. An on-line database is indispensable. One example of an existing biosurveillance system is the Exotic Pest Information Collection and Analysis (EPICA) of USDA-APHIS-PPQ; examples of initiatives that deal with pest information management are: the Global Pest and Disease Database (GPDD) and the Off-Shore Pest Information Program (OPIP) of USDA-APHIS, as well as the Biodiversity & Environmental Resource Data System (BERDS) of Belize (March *et al.*, 2008), the Global Invasive Species Database of the Invasive Species Specialist Group, and the Invasive Species Compendium of CABI. The potential usefulness and applicability of these and other projects for the GCR should be evaluated and collaborations should be developed as appropriate.

- **Hold a regional symposium on biosurveillance and pest information management** (in support of the previous recommendation). A special session at the Caribbean Food

Crops Society Meeting may also be a possibility. This event should be sponsored by the regional action group.

- **Develop effective mechanisms and procedures for translating information into action.** The most sophisticated pest information system is useless if the information does not lead to action. Every country should have an effective process in place for ensuring that incoming pest information is evaluated, action plans are developed, recommended actions are carried out, their effectiveness is assessed, and this assessment is fed back into the information system. Any processes implemented are not static, but have to be continuously scutinized, refined, and updated. The regional action group may be instrumental in coordinating the development of these processes where they do not yet exist.

- **Develop regional emergency action plans** that are triggered as soon as a country reports the introduction or interception of certain pests. These plans would include communication, survey, and control strategies. This effort should be coordinated by the regional action group.

- **Establish a regional "New Pest Advisory Group".** This would be a committee similar to and collaborating with the USDA-APHIS-PPQ New Pest Advisory Group (NPAG) to evaluate the expected impact of recently introduced pests and to recommend an appropriate response. This committee should be comprised of experts from various countries and should draw on additional expertise as needed in each case. The applicability of NPAG procedures to a regional new pest advisory group should be reviewed by a committee of the regional action action group.

- **Do not attempt to develop a *comprehensive* list of pest threats to the entire GCR.** This undertaking would have a low chance of success due to its huge scale and ever-changing information. Instead, implement a database system to record distribution data, pest survey results, pest finds, and port-of-entry interceptions from all possible sources to have the best possible and most current information on what pests are present in the GCR. This information could be used to develop pest lists for surveys; *e.g.*, if a pest is detected in one country, it makes sense for other countries to start surveying for it. The database should be coupled with a biosurveillance and notification system. Pest lists should be seen less as permanent documents and more as dynamic and constantly changing output from one large collection of information.

- **Do not base risk estimates on port interception data alone.** Often, decisions (*e.g.*, what commodity to focus inspection on, what pathways to consider high or low risk, *etc.*) are made using risk estimates based exclusively or mainly on pest interception records. Port interception records are useful for exploring pest risk; however, it is erroneus to assume that a low number of interceptions is equivalent to low risk. Of the 21 insect species that were found to be established in Florida between 1997 and 1998, only five had been intercepted more than once by PPQ at ports-of-entry in the 12 years prior to their establishment (Brodel, 2003).

- **Strive for transparency in all decisions and analyses.** Most decisions concerning safeguarding (*e.g.*, level of inspection, inspection methodology, whether something should be considered high- or low-risk, *etc.*) are made by some committee or group, either formally or informally. All decisions have to be re-evaluated periodically as the situation changes or new information becomes available. If the reasoning behind a decision is not clearly documented, it becomes impossible to evaluate the decision's validity. For the sake of continuous improvement and to reduce the possibility of errors, the reasoning behind all decisions should therefore be clearly explained and documented, and this information should be available within each government. No analysis or recommendation should be accepted by any decisionmaker unless the reasoning behind it is sufficiently clear and well-documented.

- **Agree on a common terminology.** A mutually understood terminology is a key ingredient for any successful cooperation. It is very common for people in different countries or even different groups within the same country to work off different definitions for the same terms. This discrepancy is not always obvious and may not be noticed immediately; however, it may in some cases severely affect the outcome of a cooperative effort (Roberts, 2004). A common glossary of all relevant terms should be compiled and maintained for the entire GCR. The regional action group should play a coordinating role in this undertaking. The terminology should be consistent with ISPM #5: Glossary of Phytosanitary Terms, and may possibly be used to amend it.

- **Develop voluntary codes of conduct for regional groups involved in the dispersion of exotic species** (*e.g.*, nursery trade, botanical gardens, importers/exporters, cruise ship operators, producers/refurbishers of WPM, operators of small boats and yachts, *etc.*) (March *et al.*, 2008). These codes of conduct should be drafted/compiled by a regional committee and shared throughout the GCR. For example, the National Invasive Species Strategy of the Bahamas contains voluntary codes of conduct for the government, botanical gardens, nursery professionals, the gardening public, farms, and other groups (BEST, 2003).

- **Increase the use of detector dogs wherever feasible.** Resources will never allow a thorough inspection of all pathways by human inspectors. Even in countries with relatively abundant resources, inspection cannot keep up with the ever increasing volume of incoming planes, ships, boats, mail, *etc.* Detector dogs make it possible to reliably scan a larger number of items than humans given the same amount of time. Countries with very limited resources may consider alternating a dog between pathways or even sharing a dog with other countries. Periodic inspection of a pathway is preferable to no inspection at all, as it has a deterrent effect and leads to the collection of valuable data.

- **Leverage available resources and find low-cost approaches to achieve goals.** Money and time are always in short supply, and many good ideas never come to fruition because of a lack of resources. It is therefore important to use available resources to the best possible advantage. Some ideas for how to accomplish this may be:
    - **Involve the public.** A lot of the work that needs to be done does not require professional staff. Outreach and education efforts can be easily done by citizen

volunteers. Educational materials, such as brochures or videos may be produced in a student competition at a minimal cost. Amateur naturalists can help with pest surveys and report new detections. Farmers can check traps placed in their fields and report results by phone or e-mail. Volunteer tourists even pay to be allowed to work (Vountourism.org, 2008). Certain not-for-profit organizations (*e.g.*, Partners of the Americas) can provide highly qualified subject matter experts for short-term assignments.

  - **Carry out projects on a regional rather than a country-by-country level** to save costs. For example, instead of developing a separate database for each country, develop a single database and share the development costs. (This does not necessarily mean that the data has to be shared among countries.) Instead of creating educational materials separately for each country, develop one set of materials that can be used by all countries in the GCR. In funding research projects, avoid duplication of effort by coordinating research needs region-wide.
  - **Take advantage of existing projects and products.** Sometimes the desired goal has already been achieved, or at least partially achieved, by someone else. Always explore possibilities to share into or build on the efforts of others for mutual gain. One current example would be the UNEP project GFL/-2328-2740-4995 “Mitigating the threats of invasive alien species in the insular Caribbean”.
  - **Form strong relationships with universities around the world.** Get graduate students involved in Caribbean research projects through internships and study-abroad opportunities. Offer graduate thesis project ideas. Form agreements with universities to ensure that students receive university credit for research work done in the GCR.
  - **Break work up into feasible projects.** While it is important to keep the big picture in mind, it is usually more effective to break the work up into several smaller projects rather than attempting one all-encompassing undertaking.
  - **Promote grass-roots efforts** rather than managing large-scale initiatives from the top-down. Top-down management of very complex projects that involve a high degree of uncertainty is likely to fail because of large adminstrative overhead, overwhelming complexity of decision-making, slow progress, and lack of ownership by the people who have to carry out the work. Instead, set a clear goal, establish basic guidelines, and allow the work to proceed from the bottom up.
  - **Minimize the number of groups working on similar issues in the GCR.** Commit to and invest in one or a small number of coordinating groups, rather than forming more and more similar groups with largely overlapping agendas. Too many independent groups cause confusion and dilute resources.

- **Improve collection and accessibility of traffic data at ports of entry.** All ports of entry that do not currently report traffic data should start doing so. The availability of port traffic data at an adequate level of detail is necessary for risk quantification and cost-benefit analysis regarding potential phytosanitary measures. Data format and units of measurement should be harmonized throughout the region. Relevant information includes: number and type of conveyances (vessels, airplanes, trucks, *etc.*) arriving and departing; number and size of containers arriving, departing, or re-exported and if they are full or empty; origin of containers.

- **Create and enforce phytosanitary regulations** that allow the issuing of adequate fines or other penalties for violations. Fines need to be sufficiently high in relation to the benefit of the prohibited action to have a deterrent effect.

Recommendations related to: Human Movement

- **Post signs at marinas to educate visitors about the potential consequences of transporting exotic pest species on their vessels.**

- **Increase presence and visibility of inspectors** at marinas, mainly as a deterrent measure. Publicize interceptions as a warning to potential violators.

- **Post signs at eco-tourism sites** describing acceptable behavior while visiting the site. Visitors should be instructed to remain on marked paths and to neither bring into nor take out of the area any plants, plant parts, or animals.

- **Instruct visitors to clean shoes and clothing when entering or leaving a natural or agricultural area.** Visitors should remove soil and plant seeds from shoes and clothing and inspect cuffs and Velcro® closures. (Where appropriate, consider the use of water hoses, disinfectant foot baths, metal grates in ground for cleaning shoes, *etc.*).

- **Work with tour-guides and other staff at natural or agricultural areas to educate visitors on the potential environmental and economic effects of exotic species introduction.** For example, visitors to the El Yunque rainforest in San Juan are educated on environmental considerations prior to taking a walking expedition (Johnson, 2006).

- **Educate international air travelers prior to departure and deplaning about the potential consequences (economic, environmental, personal) of transporting agricultural products.** This could be achieved by on-flight announcements, informational brochures, or on-flight or pre-flight educational videos.

- **Raise money by providing products such as postcards, calendars, or souvenirs to visitors who give a donation** (Johnson, 2006). Use the money towards the prevention of exotic pest introductions. The products themselves can be educational by providing information on exotic pests of concern, dispersal mechanisms, and possible preventative actions.

- **Implement a user fee system for eco-tourist destinations.** Funds raised through ecotourism should go to exotic species prevention and management (Hypolite *et al.*, 2002).

- **Carry out biodiversity impact studies for ecotourism sites** to anticipate environmental and economic impacts of exotic species introduction.

- **Limit access to very sensitive sites** by restricting the number of visitors, access for vehicles, density of roads and trails, availability of accomodations, *etc*.

Recommendations related to: Airline Passenger Baggage

- **Educate international air travelers prior to departure and deplaning about the potential consequences (economic, environmental, personal) of transporting agricultural products.** This could be achieved by on-flight announcements, informational brochures, or on-flight or pre-flight educational videos.

- **Remind plane passengers to consume or discard prohibited materials during flight.**
  - Announcements by the flight crew could remind travelers that they are not allowed to take certain materials into the destination countries.
  - When collecting trash before landing, the flight crew may specifically ask for fruits, vegetables, seeds, plants, meats, or other prohibited items.

- **Expand the use of detector dogs for baggage inspection.** This is a less intrusive and faster method than opening of the luggage by human inspectors.

- **Invest in research on inspection technology (***e.g.*, robotic nose**,** x-ray technology, *etc.***)**

- **Develop targeting strategies for inspection of airline passenger baggage.** Possible targeting criteria include origin of passenger, seasonality, and holidays. In order for this to be possible, a systematic data collection program has to be implemented.

Recommendations related to: International Mail

- **Post educational information at public and private mail facilities** to inform senders of the potential economic and environmental impact of exotic species introductions and to increase public awareness of phytosanitary regulations as they pertain to mail.

- **Conduct periodic data collection efforts ("blitzes") at mail facilities.** Carry out statistically-sound data collection to answer specific questions. Consider region-wide coordination and sharing of resources for carrying out blitzes. Share results region-wide.

- **Allow inspection of USPS first class mail in Puerto Rico before leaving to the United States.** The lack of authority to inspect first-class mail seriously undermines the quarantine process. Establish a PPQ working group to devise a program that will permit inspection of USPS first class mail in Puerto Rico before leaving to the United States. Current regulations (7CFR318.13 and 7CFR318.58) allow for such actions. Hawaii has developed a process for obtaining search warrants, allowing inspection of suspicious first-class packages destined to the mainland United States. A detector dog is used to establish probable cause.

- ❖ **Foster collaboration between customs officials, agricultural officials, mail facility staff, and any other groups involved in mail handling and inspection.**

- **Establish mail inspection systems** in countries where they do not yet exist. This is obviously a big and long-term undertaking that may not be immediately feasible everywhere.

- **Implement package tracking and tracing technology at mail facilities.** Improve public and private mail systems, in particular the ability to track and trace parcels.

- **Increase the man-hours spent inspecting mail packages** for quarantine materials, even if only periodically.

- **Use appropriate inspection technology** (*e.g.*, x-ray systems) at mail facilities.

- **Use detector dogs** at the mail facility.

- **Record data on pest interceptions in mail.** Collect and archive data on pest and quarantine material interceptions in mail. Ideally, the database or at least the format of the database should be region-wide.

- **Create a regional bulletin or newsletter to** share information about noteworthy pest interceptions in mail, mail inspection methodologies, relevant meetings, *etc.*

- **Conduct surveillance of commercial internet sites.** Quarantine materials (especially propagative materials) are being sold and often smuggled through mail order. USDA-SITC has attempted a surveillance initiative ("AIMS") and may be able to offer some insights.

- **Organize a regional mail handler's conference** as a formum for sharing information, ideas, strategies, technologies, *etc.* Hold mail inspector training meetings.

Recommendations related to: Maritime Traffic

- ❖ **Focus safeguarding efforts on the major transshipment ports for cargo from outside of the GCR.** The major transshipment ports (Colon, Panama; Kingston, Jamaica; Port-of-Spain, Trinidad) are where most of the cargo arrives from all over the world to be distributed within the GCR by small vessels. Focusing safeguarding efforts on these locations would require dealing with fewer entities (ports, ships, *etc.*) and may thus be easier and more efficient.

- ❖ **Monitor inter-island trade via small vessels.** Little data is available on inter-island trade, including the transshipment of cargo from one country to another via small vessels. Determine what commodities are being shipped, as well as their quantity, country of origin, country of destination, and the incidence of wood packaging material.

- **Implement risk communication strategies to educate local residents and business owners on the pest risks associated with trade.** Suggest specific strategies they can employ to reduce the risk of pest introduction.

Recommendations related to: Hitchhiker Pests

- **Encourage loading of vessels during times when the likelihood of pest entry is lowest.** For example, avoid nighttime loading because lights attract some major groups of quarantine-significant insects.

- **Clean containers and conveyances.** Evaluate effectiveness of currently used or available cleaning methods and make changes as appropriate.

- **Place traps on maritime vessels (commercial and cruise ships)** to catch insects and possibly mollusks present on vessels**.** Coordinate and share data throughout region. Ensure that traps do not attract pests onto the ship (*e.g.*, place lures/turn on trapping lights *etc.* only after ship is far enough from land). CISWG could be instrumental in coordinating the development of a trapping plan, possibly in coorperation with the U.S. Cooperative Agricultural Pest Survey (CAPS) Program and risk advisory groups such as BTAG and CRAG.

- **Monitor areas on and near the perimeter of the ports regularly** for introduced pests of particular interest (Robinson *et al.*, 2008). To reduce costs, employ the help of amateur taxonomists, university students, and qualified volunteers. Avoid attracting pests into the area (*e.g.*, through lures, lights, *etc.*).

- **Inspect empty containers, as well as containers with cargo.**

- **Minimize pest contamination on containers by:**
    - Minimizing time of container storage outdoors
    - Avoiding container storage on soil and near vegetation
    - Avoiding night-time lighting of outdoor storage areas
    - Cleaning storage areas on a regular basis
    - Cleaning inside and outside of containers after and before each use

- **Support studies to increase our understanding of the prevalence of hitchhikers on transshipped containers.** Focus on major maritime ports and airports that receive cargo from outside of the GCR. Evaluate likelihood of hitchhikers to be carried to final cargo destination given the current cargo handling procedures.

Recommendations related to: Wood Packaging Material

- **Develop a strategy to ensure adequate inspection of WPM on all agricultural and non-agricultural cargo.** Simply checking for treatment seals is not a sufficient inspection method. A certain percentage of WPM should be randomly selected and thoroughly searched for pests, both on the surface and inside the wood. All pertinent information (type of cargo, origin of cargo, presence of treatment seal, types and number of pests found, *etc.*) should be recorded and shared region-wide.

- **Make the declaration of WPM mandatory for all imports.** The presence of WPM in a shipment should be declared on the importation papers. In addition, there may be a special mark (*e.g.*, a sticker) placed on containers that have WPM in them. This will help port staff more effectively target WPM for inspection.

- **Increase region-wide inspection and identification expertise on pests associated with WPM.** Educate inspectors on how to look for pests on WPM. Ensure that identifiers have the expertise and the necessary reference material to identify the pests that are found.

- **Carry out surveys to determine the distribution of pests commonly associated with WPM outside of their native range.** Collaborate with forest services, not-for-profit organizations (*e.g.*, CABI) and the Cooperative Agricultural Pest Survey (CAPS) Program. Involve the public. Use the help of hobby biologists. Do not exclude the countries that are enforcing ISPM #15 from these survey efforts.

- **Allow entry of WPM only if bark-free.**

- **Develop a communication network to share pest interception data, as well as inspection and diagnostic techniques, training materials, *etc.***

- **Encourage research to assess the effectiveness of ISPM #15.**

Recommendations related to: Forestry

- **Hold an international congress on introduced and imminent forest pests in the GCR.** The conference may be coordinated by Carribean Invasive Species Working Group (CISWG) and may be modeled after a similar conference held by FAO in 2003 (FAO-RAP, 2005). The main objectives of the conference should be to:
  - increase awareness of the threats of invasive species to forests and forest products;
  - share information related to exotic forest pests; and
  - develop action items for regional cooperation in addressing forest pests.

- **Establish criteria for assessing invasive potential for exotic tree species that are under consideration for agroforestry.** The USDA-APHIS-PPQ-Center for Plant Health Science and Technology may be able to provide expertise in weed risk assessment.

- **Exclude tree species with high invasive potential from agroforestry systems.** Fast-growing and readily reproducing tree species are often preferred for plantation planting. However, these species also have a greater potential to become invasive. As much as possible, promote the use of local tree species in agroforestry and reforestation.

- **Carry out surveys to determine the distribution of pests commonly associated with wood and non-wood forest products outside of their native range.** The efforts of Kairo *et al.* (2003) would provide a useful foundation for this.

- **Establish Best Management Practices to reduce the potential movement of forest pests.** These could include:
  - Sanitation procedures such as cleaning forest equipment after each use
  - Prevent contamination of logs with soil or weeds
  - Prevent hitchhiker pests
  - Prevent new infestations of cut logs (protect stored logs)
  - Limit the movement of untreated firewood

Recommendations related to: Propagative Material

- **Require a weed risk assessment for the importation of plant species.** Prohibit the importation of all plant species unless they have been deemed unlikely to become invasive by a (predictive) weed risk assessment. Any country without this policy leaves a weakness in its safeguarding system. (Exceptions may be made for plants that have been historically imported at high volumes.) The Australian Weed Risk Assessment system is the most widely known and tested system of its kind (Gordon *et al.*, 2008).

- **Assess the invasiveness of plant species retrospectively** (*e.g.*, (Heffernan *et al.*, 2001, Fox *et al.*, 2005, Randall *et al.*, 2008). Retrospective assessments evaluate the invasiveness of plants some time after they have been imported. Retrospective assessments are important because a lag time may exist between species introduction and onset of invasiveness, invasiveness may change due to environmental changes, or the invasiveness potential of a species may have been misjudged in a predictive weed risk assessment (Reichard and White, 2001).

- **Draft a voluntary code of conduct for nurseries and landscaping businesses** to promote the sale and use of native and non-invasive plants. This code of conduct should stipulate that the businesses:
  - ensure that their staff is knowledgeable on the subject of invasive plants
  - help educate their customers about invasive plants
  - refrain from selling or planting species that are known to be invasive
  - clearly label native plants and foreign non-invasive plants
  - immediately report any potentially exotic pest organisms found on imported plants

- **Draft a voluntary code of conduct for local governments, resorts, hotels, and other entities that engage in large-scale landscaping.** This code of conduct should stipulate that the entities:
  - plant only native species or foreign species known to be non-invasive
  - remove plants that are becoming invasive
  - help educate their customers/residents on invasive plants

- **Draft a voluntary code of conduct for botanical gardens and arboreta.** Conclusions from the first World Botanic Gardens Congress state that "Botanic gardens and arboreta have, and continue to, contribute to this problem by promoting actually and potentially invasive plants. Botanic gardens and arboreta have a clear responsibility to adopt and demonstrate to the public a strong environmental ethic" (BGCI 2000). Code of conduct should stipulate that botanical gardens:
  - conduct invasiveness studies prior to introducing a new plant into botanic gardens, arboreta, and the landscape. Possibly model invasiveness evaluation after systems already in place at some botanic gardens that currently have evaluation systems in place (BGCI, 2000)
  - re-evaluate current plant collections for invasiveness (BGCI, 2000)
  - …"engage and educate fellow botanic gardens and arboreta, the horticulture industry, and the public about the importance of choosing and displaying ecologically responsible plant collections." (BGCI, 2000)
  - "support, contribute to, and share research that identifies problems and provides solutions" related to invasive plant species." (BGCI, 2000)

- **Develop an educational program on identification and potential impact of invasive plant species in the GCR** (Reichard and White, 2001, Waugh, 2008). This program should target the general public, as well as businesses and governments throughout the GCR. The program may be developed at universities, for example through graduate student projects.

- **Develop a certification process** that allows any entity adhering to the above-mentioned codes of contact to become a "Certified ambassador of invasive species prevention."

- **Develop sampling protocol for mites and other small arthropods.** "Visual inspection for mite infestations on large numbers of plants is inadequate […]… A sampling protocol […] would include a designated subsample of plants in a shipment. Use of either an 80% ethanol wash or a specified concentration of detergent solution would be employed […]. This assessment should be done for a minimum period of one year to identify trends and seasonal patterns of different pest mite species (as well as other arthropods) and provide assurance of compliance by foreign shippers." (Childers and Rodrigues 2005).

- **Increase attention to plant pathogens.** As much as feasible, increase the availability of molecular diagnostics. Develop a list of common pathogens of economic importance for which plant material should be tested on a regular basis. Share test results within the GCR. Use early warning and bio-surveillance systems as inputs for decision making.

- **Require phytosanitary certificates for all imports of propagative materials.** The phytosantairy certificates should indicate the species and, if applicable the variety, of the imported plants and should provide some assurance that the plant material is free of pests based on *clearly specified* inspection protocols.

- **Evaluate adequacy and reliability of procedures for issuing phytosanitary certificates.** Can the phytosanitary certificates be generally trusted? Is the staff providing the information qualified? What is the affiliation of the persons providing the information (NPPO, industry, *etc.*)? Are specific inspection guidelines in place? Is there a mechanism for error control? Is there effective communication between the importing and the exporting country?

- **Support the efforts of the IPPC to develop an international standard for plants for planting.** "International trade in plants for planting has a high potential for the introduction of regulated pests. Current phytosanitary measures that rely mainly on treatments and inspections are, in some cases, inadequate to mitigate the risks. Harmonized procedures for phytosanitary security of traded plants for planting are necessary to allow increased trade while minimizing phytosanitary risks and unnecessary delays. The expert working group is tasked with drafting a standard that will outline the main criteria for the identification and application of phytosanitary measures for the production and international movement of plants for planting (excluding seeds), while also providing guidance to help identify and categorize the risks." (IPPC, 2008)

- **Record information on propagative material imported** by plant species, with information on variety, type of material (roots, cuttings, *etc.*), country of origin, growing and inspection practices followed, date of importation, and amount imported in consistent units.

- *In the United States:* **Give strong priority to the improvement of "quarantine 37"**, building on the recommendations of Tschanz and Lehtonen (2005). If necessary, divert scientific, risk analysis, and regulatory resources away from fruit and vegetable towards propagative material imports.

- **Implement systematic data collection efforts** to assess the pest risk associated with at least the most common imports of propagative materials. These data collection efforts should be based on a statistically sound sampling scheme (validated by a qualified statistician) and should follow a clearly documented inspection protocol. This protocol should describe in detail the inspection methods to be followed (*e.g.*, detergent wash, diagnostic tests for pathogens, use of hand lens, *etc.*). Consider making resources available to fund this work as graduate student research. The advantages of this approach over using port-of-entry personnel would include: lower cost, less diversion of inspectors, more objectivity and reliability of research, and better distribution and documentation of results through the scientific publication process.

- **Implement a systems approach** to reduce the pest risk associated with the propagative materials that pose the highest risk of pest introduction. The systems approach should be customized for each commodity and should be developed collaboratively by the importing and the exporting countries. The systems approach may contain components such as scouting, pesticide applications, biological control, reduction of fertilizer levels, routine diagnostic tests for pathogens, basic sanitation practices (*e.g.*, washing of shoes and equipment, *etc.*), pre-shipment inspection, quarantine treatments, *etc.* The systems approach developed for Costa Rican *Dracaena* plants for importation into the United States may serve as one example of a potentially very successful and mutually beneficial program.

Recommendations related to: Natural Spread

- ❖ **Conduct annual surveys to monitor the arrival of new pests in an area.**
- ❖ **Use predictive modeling (*e.g.*, degree-day models, *etc.*) for timing of surveys.**
- **Use sterile insect technique (SIT).** Base SIT programs on a target pest list.
- **Develop host-free zones for targeted pests.**
- **Develop biological control methods for targeted pests.**
- **Determine the origin of invasive pests in the GCR.** Because most information about the natural spread of pests is anecdotal, the knowledge of where a pest originated from would be a useful start in understanding natural pest movement. Obviously, it is generally very difficult and often not possible to determine the origin of a pest. Modern technologies, such as trace element or DNA analysis may be useful in some cases.

Introduction

Like many other areas of the world, the Greater Caribbean Region (GCR) is suffering considerable economic and environmental impacts due to the introduction of exotic plant pests. Examples of some recently introduced pests include the pink hibiscus mealybug, *Maconellicoccus hirsutus* (Hemiptera: Pseudococcidae), from Asia, which spread throughout the GCR in less than 10 years, causing crop losses in the millions. Similarly, the red palm mite, *Raoiella indica* (Acari: Tenuipalpidae), is quickly expanding its range throughout the region after being detected in Martinique in 2004 (Flechtmann and Etienne, 2004). Black Sigatoka, *Mycosphaerella fijiensis* (Ascomycetes: Mycosphaerellales), the mango seed weevil, *Sternochetus mangiferae* (Coleoptera: Curculionidae), and the giant African snail, *Achatina fulica* (Gastropoda) are just a few more examples of economically significant pests introduced into the GCR.

While we do not know exactly how many exotic species have already established in the GCR, there is no doubt that their number is in the hundreds and is quickly growing. Frank and Thomas (2004) estimated that every year about 10 new species become established in Florida alone. Kairo *et al.* (2003) provide a list of over 550 exotic species in the insular Caribbean. Frank and McCoy (1992) list over 270 exotic insects that have established in Florida since 1970. As the land areas in and around the Caribbean share similar climates and vegetation, species that become established in one part of the region are potentially able to invade most other parts.

The GCR is composed of a multitude of mostly small countries and territories with a diversity of political systems. While a number of organizations with agricultural focus are active in the GCR, no single regional plant protection organization exists (Kairo *et al.*, 2003). Resources available for the prevention and management of exotic pest introductions are limited and so is knowledge about the relative importance of different pathways of introductions.

This report is the result of a collaboration between the Caribbean Invasive Species Working Group (CISWG) and the United States Department of Agriculture, Plant Protection and Quarantine (USDA-PPQ). Its objective is to contribute to an improved understanding of pathways of plant pest movement as they pertain to the entire GCR, thereby helping CISWG to enhance its Caribbean Regional Invasive Species Intervention Strategy (CRISIS) for preventing the introduction and spread of exotic pests.

The scope of the report includes all terrestrial, non-vertebrate plant pests, such as insects, mites, plant pathogens, nematodes, mollusks, and weeds. For the purposes of this report, the Greater Caribbean Region is defined as all countries bordering the Caribbean Sea, plus the Bahamas, Turks and Caicos, El Salvador, Guyana, Suriname, and the U.S. Gulf States. The pest risk *to* Mexico, Venezuela, and Colombia is not addressed in this report, though these countries were considered as sources of pest risk.

This document is a collection of chapters, each of which explores a different pathway of pest movement. Although the chapters can be read independently of each other, there is considerable overlap between topics. The pathways discussed are: human movement, airline passenger baggage, mail, maritime traffic, hitchhikers, wood packaging material, forestry, propagative materials, and natural spread. A list of recommendations for improved safeguarding is provided at the end of each chapter. The recommendations that have the highest expected cost-benefit ratio are preceded by a ❖.

The discussion focuses on pest movement and entry. The question of establishment, an important topic in its own right, has been purposely omitted from the scope of this report.

This report does not make the claim to answer all questions, to solve all problems, or to even discuss all possible pathways of pest movement; rather, it is meant to be a starting point for discussion and further study. It is hoped that this report will foster dialog and collaboration among the Caribbean nations and will lay the groundwork for other, similar projects.

Chapter 1: Human Movement

Introduction

The introduction of pests into new locations has been closely linked to the movement of humans. For example, Lonsdale (1999), accounting for site size effects, showed that the number of exotic weeds in a particular site increases with the number of visitors.

As the most heavily touristed region in the world (Padilla and McElroy, 2005), the GCR is faced with the challenge of managing this risk of exotic pest introduction. In the insular Caribbean, the travel industry is among the most important industries, comprising almost 15% of the Gross Domestic Product (GDP) and providing approximately 13% of total employment (WTTC, 2008). In 2006, international tourist arrivals numbered 19.4 million, 7 million, and 18.7 million for the Caribbean islands, Central America, and South America, respectively (UNWTO, 2008).

Travelers may arrive by one of three basic modes: air, water, or land. The GCR has almost 1,000 airports (Aircraft Charter World, 1998, James, 2008), and the majority of all travelers—both from within and outside of the Caribbean—arrive by air (UNWTO, 2006). Cruise ships, departing mainly from North America, also bring a substantial number of travelers into the GCR (FCCA, 2008). Travelers may arrive by water on ferries or on personal or chartered boats or yachts. Access across land borders is possible in the case of North, Central, and South American countries, as well as the countries on the islands of Hispaniola (Haiti and the Dominican Republic) and Saint Martin (French Saint Martin and Dutch Saint Maarten). Once in the GCR, it is common for tourists to move between countries ("island-hop") by regional flight, small boat, ferry, or cruise ship.

In this chapter, we address each of the above-mentioned basic modes of human movement (air, water, and land) into and within the GCR and discuss the potential of each to serve as pathways for exotic pest introduction. The pest risk associated with airline passenger baggage is analyzed in detail in its own chapter (see Chapter 2). The pest risk associated with hitchhiker pests on vessels and airplanes is also discussed separately (see Chapter 5).

Discussion

Persons visiting an area may intentionally or unintentionally spread plant pests in several different ways: they may be carrying the pest on themselves, their clothing, or their shoes; they may unintentionally transport the pest on certain products such as handicrafts or plant parts brought to or taken from the area; or they may intentionally collect the pest (*e.g.*, insects, snails, tree seeds, or whole plants) to take it to a different location.

Data on the frequency of such events is scarce. Given that clothing and shoes, as well as most items picked up by travelers with the purpose of transporting them to a different location will most likely be carried inside the travelers' baggage at some point during the trip, the quantitative analysis of the risk associated with airline passenger baggage provided in a separate chapter of this report is relevant here (see Chapter 2).

Apart from this, most of the available information is anecdotal and non-quantitative. For example, the plant pathogen *Phytophthora ramorum* (Oomycetes, Pythiales), found in greater incidence on hiking trails and public lands than in minimally disturbed areas, appears to be distributed via human activities such as hiking (Cushman and Meentemeyer, 2008). Spores of the fungus *Puccinia striiformis* f. sp. *tritici* (Uredinales: Pucciniaceae) can remain viable on clothing for at least one week (Wellings *et al.*, 1987). Similarly, conidia of *Colletotrichum acutatum* (Ascomycota) may remain viable for long periods of time in dry soil or on clothing (Norman and Strandberg, 1997); and land snails and slugs are believed to have been accidentally introduced into the Pacific Islands in soil on shoes (Cowie, 2001). DiThomaso (2000) points out the possibility that travelers may carry noxious weed seeds in soil particles attached to shoes and boots; and numerous pest fact sheets mention the possibility of spreading via clothing or shoes plant pathogens such as:

- *Puccinia graminis* f. sp. *tritici* (Uredinales: Pucciniaceae), the causal agent of the wheat stem rust Ug-99 (Grains Research and Development Corporation, 2008);
- *Moniliophthora roreri* (Agaricales: Marasmiaceae), causal agent of frosty pod rot (CABI, 2008);
- Pepino mosaic virus (PepMV) (Ferguson, 2001);
- *Xanthomonas axonopodis* (Xanthomonadales: Xanthomonadaceae), causal agent of citrus canker (Telford, 2008);
- *Puccinia horiana* (Uredinales: Pucciniaceae), causal agent of chrysanthemum white rust (Callahan, 2003);
- *Phakopsora pachyrhizi* (Uredinales: Phakopsoraceae), causal agent of soybean rust (USDA-APHIS-PPQ, 2003); or
- Nematodes (Crow and Dunn, 2005).

Many plants have evolved special adaptations enabling their seeds to adhere to the fur of animals (Bullock and Primack, 1977), and these same adaptations will make the seeds adhere to human clothing as well. Lonsdale (1999) showed that the number of exotic weeds in a particular site increases with the number of visitors. Several weed species in Mexico have been shown to be dispersed on human clothing (Vibrans, 1999). In a study by Whinam *et al.* (2005), inspection of expeditionary equipment revealed that viable seeds were carried on clothing to overseas locations. A total of 981 propagules (seeds and fruits) and five moss shoots were collected from the clothing and equipment of 44 expeditioners. These propagules comprised 90 species from 15 families. Outdoor equipment and equipment cases (particularly daypacks) were found with seeds on or in them. Pockets, seams, and cuffs of outdoor clothing such as gaiters, jackets, and socks also collected propagules. Seeds were found under the tongue, innersole, and in the tread of walking boots. Clothing and outdoor items with Velcro® fasteners were identified as the highest-risk items.

Also of concern is the deliberate movement of organisms or objects which are pests or may harbor pests. Based on our personal experience, it is not uncommon for travelers to actively collect or purchase viable plants or plant parts, live insects or snails, or pieces of wood or small quantities of soil that may contain pest organisms. Seeds, plants, and flower bulbs have been intercepted in airline passenger baggage (USDA, 2008d), showing that these items are indeed being carried by travelers. Rare orchids and endangered cycads from Asia, Australia, and Africa have been smuggled into the United States for resale (Stokes, 2001). Given the diversity and beauty of tropical plants and animals, it seems likely that many travelers would be tempted to take along plant parts or small animals as souvenirs. If these travelers visit multiple locations in the GCR, which is common especially among cruise ship passengers, there is a chance that pests could spread from one location to the next. Residents of the GCR may be tempted to take plants or seeds from visited locations with similar climates either within or outside of the GCR for planting in their own yards.

Image 1.1 Handicrafts made of palm leaves for sale in Puerto Rico.

Handicrafts sold at markets throughout the GCR may also present a pest risk. For example, at a tourist market in Old San Juan, Puerto Rico, baskets and animals made out of palm leaves were offered for sale (**Image 1.1**). These items have the potential to harbor plant pests, as evidenced by the detection of live red palm mites, *Raoiella indica* (Acari: Tenuipalpidae), in palm frond hats made in the Dominican Republic and brought by cruise ship passengers to Palm Beach, Florida (Apgar, 2007, Welbourn, 2007). Hats are of special concern, because people wear them as they walk about, and they are at a height where contact with vegetation is easily possible. But it is not only Caribbean products that present a pest risk. People from other countries visiting friends or relatives in the GCR are likely to purchase local handicrafts as gifts. Furthermore, many of the handicrafts sold as souvenirs in Caribbean countries are actually made in China, India, or other Asian countries (personal observation), and some of them (*e.g.*, baskets, wood carvings, *etc.*) could conceivably present a pest risk. Similarly, wooden products such as bonsai trees, artificial Christmas trees, and bamboo stakes may be vehicles for the movement of wood-boring pests (Haugen and Iede, 2001).

While we do not have sufficient information to quantify the likelihood of pest introduction per traveler, it is obvious that the frequency of traveler-related pest introduction into an area is a direct function of the number of travelers entering per unit of time. In 2006, the Caribbean islands documented 19.4 million international tourist arrivals, Central American countries reported almost 7 million, and those for South America numbered 18.7 million (UNWTO, 2008). Experts project a 3.3% annual growth of tourist numbers for the next 10 years (WTTC, 2008).

Table 1.1 shows tourist arrivals for 2006. Tourist data captures arrivals of visitors staying more than 24 hours. The Dominican Republic reported the greatest number of tourist arrivals (almost 4 million), followed by Florida (3.5 million) and Cuba (2.2 million).

In 2006, the United States provided the largest source of tourists traveling to the insular Caribbean, with well over five million arrivals (**Figure 1.1**) (CTO, 2007). European tourists represented about a quarter of all tourist arrivals, followed by Canada, with almost 1.5 million arrivals (CTO, 2007).

Pattullo (1996a) pointed out that different nationalities have preferences for different destinations. U.S. travelers tend to visit Puerto Rico (27% of U.S. tourists in 2004), the Bahamas (12%), Jamaica (9%), the Dominican Republic (8%), Aruba (5%), and the U.S. Virgin Islands (5%), with the remaining tourists visiting Mexico (15%) or other destinations in the GCR (19%) (CTO, 2006). British travelers generally prefer the former British colonies (Jamaica, Barbados, Antigua and Barbuda, Saint Lucia, and the Bahamas) (Pattullo, 1996a), while Germans favor the Dominican Republic and Cuba, and French visitors prefer the French territories of Martinique and Guadeloupe in addition to Cuba and the Dominican Republic (Pattullo, 1996a).

The origin and destination preferences of travelers may be useful for determining which pests could be introduced via human movement. For example, Puerto Rico and the Bahamas may prefer to focus on pests present in the United States (and vice versa), while the Dominican Republic and Cuba should look to Germany and France (and vice versa) when seeking to identify potential pest threats.

Another factor impacting the likelihood of travelers to introduce pests is travel reason. A quantitative analysis of the pest risk associated with airline passengers entering the United States showed that persons visiting family, and—to a lesser extent—persons visiting friends, have a higher likelihood of carrying quarantine materials (QMs) than either vacationers or business travelers (see Chapter 2). However, this may not be the case for other countries of destination in the GCR. Given that the United States is an immigration country, travelers to the United States in the "visit friends" and "visit family" categories would likely be either persons from foreign countries visiting relatives who live in the United States, or U.S. residents of foreign origin returning from family/friend visits in their home country. In either case, they are likely to bring QMs such as fruits and vegetables (possibly home-grown) from a foreign country into the United States. On the other hand, most of the other countries in the GCR are sources of emigration to the United States, Canada, and the European Union (United Nations, 2005). Thus, travelers in the "visit family" and "visit friends" categories who enter these Caribbean countries would not be as likely to bring in QMs; rather, they may be expected to bring electronics, clothing, and other types of gifts that are more inexpensive or more easily available in the immigration countries.

Data available for the insular Caribbean, Guyana, and Suriname show that the majority of all visitors to these countries (approximately 80%) travel for leisure, which includes activities such as recreation, holiday, shopping, sports and cultural events, and visiting family and/or friends (CTO, 2006). Business travel, including mission trips, meetings, and paid study and research, accounts for approximately 10% of all visitor arrivals, and the remaining 10% comprises all other travel reasons (including health treatment, religious pilgrimage, and aircraft and ship crew arrivals) (CTO, 2006).

During 2006, the peak numbers of visitors were recorded in March and July, while May and September represented dips in tourist numbers (**Figure 1.2**). This is consistent with trends observed in 2003 and 2004 (CTO, 2006). The high numbers of arrivals in March and July coincide with school vacations in the United States and other countries. With a large percentage of visitors to the Caribbean traveling from the United States (CTO, 2007), it is not surprising to see this seasonal trend. The arrival of large numbers of visitors in these months may mean increased pest risk during these times, especially in July, when pest activity in the United States is at its highest.

Three relatively recent trends emerging in the Caribbean tourism industry are ecotourism, sports tourism, and the "private island" experience. Ecotourism seeks to unite the traveler with the natural environment and may offer such experiences as visits to ancient ruins and historic cities, wildlife tours, river tubing, mountain biking, and hiking (Johnson, 2006). Noting that there is a largely untapped market for sports tourism, a number of individuals in the tourism sector are encouraging sports education and further development of the sports tourism sector in the GCR (Holder, 2003, Sinclair, 2005). Cruise ship operators have begun to promote the private island experience; remote island destinations offer visitors a secluded environment and an experience quite different from traditional stops at large ports-of-call (Wilkinson, 2006).

The development of each of these niche markets may lead to increased tourism. For example, the English-speaking areas of the GCR experienced an economic boost as a result of the 2007 Cricket World Cup taking place in the West Indies (CCAA, 2007). Ecotourism worldwide has grown by 20-34% annually (Mastny, 2001, TIES, 2006) since its beginnings in the 1990s, and a growing trend may also be expected for the Caribbean.

Not only would increased tourism cause the risk of exotic pest introductions to grow, but ecotourism, private island experiences, and certain types of outdoor sports may exacerbate the impact of exotic pest introductions by bringing people into closer contact with the natural environment and with pristine ecosystems. Tourist activities, such as the use of all-terrain vehicles or mountain-bikes, may disturb fragile ecosystems (Johnson, 2006) and create an environment that is more favorable to the establishment of non-native species. The kind of tourist who is fond of nature may be likely to collect living plants, seeds, insects, or snails as souvenirs and either inadvertently or intentionally spread them to other locations within the GCR.

Pathway: Air Travel

The Caribbean's tourism industry is largely dependent on air transportation (Bertrand, 2007). Its international airports primarily receive travelers from outside the GCR (Pattullo, 1996c), while regional airports facilitate travel within the region. The GCR has almost 1,000 airports[1] (Aircraft Charter World, 1998, James, 2008), the vast majority of which are located in the U.S. states bordering the Gulf of Mexico (Aircraft Charter World, 1998). The insular Caribbean has 53 airports, including approximately 20 international airports, which are widely distributed throughout the region (James, 2008).

In a study of interceptions occurring over a 17-year period at U.S. ports of entry, McCullough *et al.* (2006) found that 62% of intercepted pests were associated with baggage. The authors identified Mexico, Central and South America, the insular Caribbean, and Asia as common

[1] Includes public, private, and military airports.

origins for the pest interceptions (McCullough *et al.*, 2006). In 2007, baggage inspections at airports in U.S. states located in the GCR (Florida, Alabama, Louisiana, Mississippi, and Texas) resulted in 126,136 plant QM interceptions, 374 soil interceptions (USDA, 2008f), and 4,049 pest interceptions (3,620 of them U.S. quarantine pests) (USDA, 2008d).

The level of airline passenger inspection varies among Caribbean countries and even among the different airports of the same country. In the United States, CBP subjects airline passengers to agricultural inspection; however, the level of scrutiny varies between flights, depending on the origin of the flight, the time it lands, the origin of other flights landing at the same time, the number of inspectors available, and other factors. For the most part, inspection of international airline passsengers traveling to the United States takes place at U.S. airports, but there are also preclearance operations at airports in Aruba, Bahamas, Bermuda, Canada, and Ireland (CBP, 2006). The luggage of air passengers traveling from Puerto Rico, the U.S. Virgin Islands, or Hawaii to the U.S. mainland or one of the previously mentioned locations is inspected prior to departure. However, in some cases inspection levels have not been able to keep up with growing passenger numbers. While the number of passengers traveling from Aguadilla, Mayaguez and Ponce, Puerto Rico to the U.S. mainland increased by 65% from 2.5 million in 2005 to 3.8 million in 2007, the number of passengers inspected grew by only 50% during the same time period (USDA-APHIS-PPQ, 2008e). Travelers from the U.S. mainland to Puerto Rico or the U.S. Virgin Islands are not subject to agricultural inspections by CBP. Regarding airline passenger baggage, it may therefore be more likely for pests to be carried from the U.S. mainland to the Caribbean rather than the other way around.

Martinique regulations prohibit the importation of any kind of plants or unprocessed plant products by airline passengers from any origin (Iotti, 2008). Inspections focus mainly on flights from South America, which have been identified as high-risk. Twice per month, flights are inspected at a 100% inspection rate, passing bags through x-ray scanners, then interviewing travelers and inspecting baggage contents as necessary. Flights originating in France are not inspected. Customs officers collaborate closely with the plant protection organization by alerting them of detections of agricultural interest (Ferguson and Schwartzburg, 2008). Flights from Guayana and Guadeloupe seem to be regarded as presenting the highest phytosanitary risk (Iotti, 2008). A propensity of the inhabitants of Martinique to bring rare plants onto the island for planting in their gardens has been noted (Iotti, 2008).

The island of Trinidad has a much better developed quarantine service than the island of Tobago, which has recently started receiving direct international flights. Previously, all international flights landed in Trinidad. There are no agricultural inspections between the islands of Trinidad and Tobago (Bertone and Gutierrez, 2008).

Several experts we interviewed in Jamaica thought that airline passenger baggage was a major pathway for pest introduction. The culprits were usually believed to be Jamaicans returning from abroad. The opinion was also that these travelers were not aware of the potential consequences of species introductions (Schwartzburg and Robertson, 2008).

Pathway: Cruise Ships

In 2007, the cruise industry carried a record 12.6 million passengers worldwide, a 4.1% increase over 2006 (FCCA, 2008)[2]. This growth trend is expected to continue (Wilkinson, 2006).

Over 10 million cruise passengers departed from North America in 2007. Almost half (61% during October through March; 23% during April through September) of all North American cruise itineraries are headed to the Caribbean (FCCA, 2008).

Three companies dominate the worldwide cruise market: Carnival, Royal Caribbean, and Star Group (Norwegian Cruise Line) (Johnson, 2002, Wilkinson, 2006, MARAD, 2007). In 2006, these companies accounted for 95% of passenger nights[3], with Carnival accounting for over half of passenger nights for the year (MARAD, 2007).

Miami, Florida dominates as the departure port supporting the most passengers (1.89 million passengers or 19% of all North American passengers) (MARAD, 2007). Also in the top five in terms of departing cruise passengers are: Cape Canaveral, Florida; Fort Lauderdale, Florida; Galveston, Texas; and Los Angeles, California.

The destinations in the GCR most visited by North American cruise passengers in 2006 were:

- Western Caribbean[4] – 32% of passengers,
- Bahamas – 15% of passengers,
- Eastern Caribbean[5] – 14% of passengers, and
- Southern Caribbean[6] – 8% of passengers (MARAD, 2007).

Table 1.2 shows excursionist[7] arrivals for 2006. While excursionist arrival data may include maritime passengers arriving on small boats or ferries, it primarily represents arrivals of cruise ship passengers. The Bahamas reported the greatest number of excursionist arrivals (approximately 3 million). The Cayman Islands, the U.S. Virgin Islands, and the Netherlands Antilles each reported close to 2 million excursionist arrivals.

Similar to airline passengers, cruise ship passengers have the potential to carry weed seeds, plant pathogens, or small insects on their shoes or clothing. The majority of multi-destination visitors in the Caribbean are cruise passengers (Garraway, 2006), and because these visits to climatically similar destinations occur within a short time frame, it is quite possible that cruise passengers may carry viable plant pests to a new location that is suitable for survival of the pest, especially with future trends (*e.g.*, ecotourism, private island experience, *etc.*) leading to more natural and

[2]Cruise passenger numbers for 2007 reported from this source are based on third quarter 2007 results and fourth quarter 2007 estimates.
[3]One passenger night is equivalent to one passenger spending one night on a cruise ship; one passenger spending four nights would equal four passenger nights.
[4] Western Caribbean: west of Haiti; includes ports in Mexico, Central America, and Colombia. Note that Mexico is not included in this analysis.
[5] Eastern Caribbean: as far south as Saint Martin and as far west as Haiti.
[6] Southern Caribbean: south of Saint Martin to northern coast of South America as far as Aruba. Note that Venezuela is not included in this analysis.
[7] Excursionist: visitor who stays for less than 24 hours and does not stay overnight.

pristine areas being visited by cruise passengers. Cruise ship passengers are also likely to visit local markets where they may buy certain handicrafts or other items that could harbor plant pests.

As cruise ships offer an abundance of food, cruise passengers are unlikely to bring food items such as fresh fruits or vegetables with them on board for consumption. For customer satisfaction, the cruise line must provide fresh food products throughout the cruise. The majority of the food served on the cruise ship is bought from suppliers at the home port (Erkoc *et al.*, 2005). While cruise lines may occasionally make additional food purchases from local markets at ports-of-call, they usually try to avoid such purchases to minimize costs. For obvious reasons, the cruise ship company has a strong interest in purchasing only produce that is free of pests.

While passengers may conceivably take fresh produce from the ship to eat during an excursion and may dispose of the fruit before re-entering the ship, this would not occur very frequently and involve only small amounts of produce that would be unlikely to harbor pests.

Ports routinely utilized by cruise ships have many street vendors who sell fresh produce (fruit, nuts, and vegetables). Although signs clearly posted in secure ship boarding areas indicate that agricultural products need to be declared, in general, inspections do not appear to target agricultural violations (Neeley, 2008). If the cruise passenger disposes of the local produce at another port-of-call or at their country of origin, then there may be a (probably very small) chance of pest introduction into the new area.

Inspection procedures for cruise ship passengers vary among GCR countries. In the United States, rules state: "passengers and baggage on cruise ships with Caribbean, Mexico or Bermuda itineraries are not routinely inspected by CBP. CBP/APHIS will periodically monitor the clearance of passengers and baggage to evaluate the risk of prohibited agricultural articles that may be associated with passengers and baggage." and "Officials of the cruise ship are responsible for educating passengers and crew members concerning the requirements for bringing agricultural articles off the ship at the U.S. Port of Entry. Information should be provided using signs at all exits from the vessel, audio and/or video presentations, and amnesty bins. Information provided to passengers and crew must be approved by CBP/APHIS prior to distribution". These rules are laid out in a compliance agreement with the cruise ship. The agreement may be revoked by CBP at any time for noncompliance (USDA-APHIS-PPQ, 2008d).

The ports of Quetzal and San José, Guatemala receive over 50 cruise ships per year, mainly during the month of January. Passenger baggage is not inspected. Inspections are performed on hulls, food provisions, and garbage. Usually, no quarantine materials are found (Meissner and Schwartzburg, 2008). Cruise ships often dock in Fort-de-France, Martinique for a few hours stay, and passengers are not subject to agricultural inspection at arrival or departure (Ferguson and Schwartzburg, 2008).

U.S. port of entry inspections of maritime passenger baggage in 2007 yielded 22,259 plant QM interceptions and six soil interceptions at marine ports located in U.S. states in the GCR (Florida, Alabama, Louisiana, Mississippi, and Texas) (USDA, 2008f). In the same year, 35 pest interceptions—19 of them quarantine pests for the United States—were documented at these same ports from maritime (primarily cruise ship[8]) baggage (USDA, 2008d) (**Table 1.3**). The majority of these pest interceptions were associated with leaves of the coconut palm, *Cocos nucifera*, presumably in the form of handicrafts. At least 28 of the 35 pest interceptions were from vessels originating in the GCR or Mexico (USDA, 2008d). These interceptions of plant QMs and of plant pests indicate that maritime passenger baggage is an important pathway for the movement of pests. It should be noted that these interceptions were the result of special blitzes targeting red palm mite; routine inspections result in fewer interceptions, *i.e.*, lower interception numbers during other time periods do not necessarily indicate lower approach rates.

Pathway: Private Boats and Small Commercial Vessels

Private yachts and small commercial vessels travel constantly between nations of the GCR (Pattullo, 1996b) and nearby countries. In many cases, inspection of these vessels is not feasible, which means that private vessels often return to marinas and private docks without any contact with an agricultural inspector. For example, at the Marina Puerto del Rey, the largest private marina in the Caribbean, arriving vessels are often cleared by radio and are not boarded by an inspector (Ruiz, 2007). The same is true in Florida (Lemay *et al.*, 2008), Guatemala (Meissner and Schwartzburg, 2008) and presumably in other locations throughout the Caribbean, as well.

Visitors traveling by yacht depend on local markets for provisions, and farmers often supply agricultural products directly to sailors at marinas (Pattullo, 1996b). In some cases, sales to sailors are a primary source of income (Pattullo, 1996b).

Small vessels are also frequently used to transport agricultural commodities, including propagative materials for commerce (Boerne, 1999). There is a chance that these agricultural products may be infested with pests, which may thus be transported to new locations. New pests establish in the GCR on a constant basis and are unlikely to be detected by local farmers--and even the scientific community--unless they cause noticeable crop damage.

For example, between Trinidad and Venezuela, there is frequent informal trade involving foods, fruits, vegetables, as well as live animals. It is suspected that *Mycospharella fijiensis*, the causal agent of the black Sigatoka disease entered Trinidad via this pathway, and there is concern that *Moniliophthora roreri*, the causal agent of frosty pod of cocoa may spread to Trinidad in the same manner (Bertone and Gutierrez, 2008).

Officials in Martinique pointed out the impossibility of controlling the traffic of small boats between the Caribbean islands. These boats often carry plant materials, either for personal use of for small-scale trading. At the Fisherman's Harbor in Fort-de-France all fishing boats are inspected once a week. They often carry crates of produce. Typical items carried for small-scale commerce with loal merchants are rrot crops like yams or taro, or fruits, like avocados. One concern is that fishermen often wrap their fish in banana leaves for transport between islands. This represents a risk of introducing black sigatoga into Martinique, where bananas are the major agricultural crop (Ferguson and Schwartzburg, 2008).

[8]The datasource (USDA 2008) does not specify vessel type; however, in many cases a ship name is listed, providing some indication of the identity of the vessel.

Private boats and other small vessels may also transport plants or propagative material. Often, private vessels return to marinas and private docks without any contact with an agricultural inspector. Pests in association with plants and propagative material will have the best chance of surviving in their new environment. Therefore, this pathway is of great concern.

Pathway: Land Borders

In the Insular Caribbean, only the islands of Hispaniola and Saint Martin are home to more than one country and can be accessed via land borders. On the other hand, all of the Central and South American countries included in the scope of this report share land borders with at least two other countries. In the following, we describe the situation at some of these borders and discuss the pest risk they present.

Land borders in the Insular Caribbean. Haiti and the Dominican Republic are connected by a 360 km land border that is frequently crossed by migrant workers from Haiti (CIA, 2008). Haitian and Dominican officials estimated that several hundred Haitians crossed the border daily (Navarro, 1999). As many as 8,000 Haitians cross into the Dominican Republic twice-weekly for market days held in the border town of Dajabon (Navarro, 1999). On the other hand, movement of tourists across this border is almost non-existent. Haiti sees few tourists other than the cruise passengers who visit a locked and guarded beach compound (Anonymous, 2008b). Pest movement across the Haitian/Dominican Republic border would be expected to occur primarily through migrant workers who may carry plants or plant products with them across the border or by natural spread.

The island of Saint Martin holds the distinction of being the smallest landmass in the world shared by two countries (CIA, 2008). French Saint Martin (northern region) and Dutch Saint Maarten (southern region) share a border that is only 15 km long (CIA, 2008). Given the small size of the island and the fact that human movement across the border is free and easy (Chase, 1996), pests are expected to move just as easily across this border.

Mexico–Guatemala border. The border between Mexico and Guatemala is approximately 1,000 km long. About 36 border crossings have been identified; however, only eight of them are regulated (Solís, 2005). Many of the border crossings, such as the Puente Binacional connecting Ciudad Hidalgo to Tecún Umán, facilitate an abundant circulation of travelers and merchandise, both of which are often transported on tricycles. There is a vivid commercial interchange between the people of both countries, of basic agricultural items and handicrafts (Núñez, 2007). A large number of Mexicans and Guatemalans cross the border legally on a daily basis, but there is also a great amount of illegal human movement, mainly from south to north. The National Migration Institute (Instituto Nacional de Migración – INM) estimates that approximately two million crossings occur annually on the Mexico-Guatemala border. In addition, there is a number of legal and illegal agricultural day workers, as well as day visitors crossing the border for shopping purposes (Solís, 2005).

Table 1.4 illustrates the dynamics at four major border crossings. More than three times as many people move from Guatemala into Mexico than from Mexico to Guatemala. However, a large number also enter Mexico to work in the agricultural sector (**Table 1.5**). Originally, they were employed mainly on the coffee plantations of Chiapas, but in more recent years, there has also been a growing demand in banana, sugarcane, and mango plantations (Solís, 2005).

Belize's borders with Mexico and Guatemala. English-speaking Belize serves as a transit country for a small percentage of Central Americans headed north (the majority transit via Mexico) (Mahler and Ugrina, 2006). Land borders with Guatemala and Mexico are 266 km and 250 km long, respectively (CIA, 2008). Belize, despite not sharing a land border with Honduras, regularly receives temporary workers from Honduras who help to harvest sugarcane and coffee (Caniz, 2008). Temporary workers who enter Guatemala through official ports of entry are subjected to agricultural inspections. Of more concern are the temporary workers who come ashore at docks other than official ports of entry. In these cases, there is speculation that these workers enter Belize with infested fruit fly host material, thus introducing the unwanted Medfly, *Ceratitis capitata* (Diptera: Tephritidae), and prompting emergency eradication efforts (Caniz, 2008).

The border between Nicaragua and Costa Rica. A large number of immigrants from Nicaragua, attracted by the availability of more jobs and better salaries than in their home country, have entered Costa Rica over the past decade. Immigrants from Nicaragua presently constitute approximately six to eight percent of all inhabitants of Costa Rica (Marquette, 2006). Most of the immigrants reside permanently in Costa Rica, but there may be as many as 100,000 seasonal migrants at peak harvest times. In addition, illegal immigration is believed to be common, although there are no official statistics confirming this (Marquette, 2006). Approximately one quarter of the Nicaraguan immigrants in Costa Rica are employed in the agricultural sector (Marquette, 2006), which brings them into close contact with plants and soil and with plant pests such as pathogens, weed seeds, nematodes, and insects. For example, at the Del Oro citrus farm located about 10 miles from the Nicaraguan border in Santa Cruz, Costa Rica, farm workers are almost exclusively from Nicaragua (Bertone and Meissner, 2008b). Nicaraguans living in Costa Rica regularly travel to their home country—often by bus—to visit family and friends, especially during the holiday seasons. This leads to an ongoing interchange of items, some of them of agricultural quarantine significance, between the two countries.

The Costa Rican Department of Agriculture (MAG) inspects cars, trucks, buses, and pedestrians entering Costa Rica from Nicaragua, working very closely with other agencies such as the border police. Interceptions of agricultural quarantine materials are very common. The coffee berry borer, *Hypothenemus hampei* (Coleoptera: Curculionidae: Scolytinae), a serious agricultural pest, is believed to have been inadvertently introduced into Costa Rica by pedestrians crossing the border from Nicaragua in 1983 (Bertone and Meissner, 2008b).

Other land borders in Central America. Other land borders in Central America are the borders between Guatemala and Honduras (256 km), Guatemala and El Salvador (203 km), El Salvador and Honduras (342 km), Honduras and Nicaragua (922 km), Costa Rica and Panama (330 km), and Panama and Colombia (225 km) (CIA, 2008)

Crossing land borders connecting Guatemala, El Salvador, Honduras, and Nicaragua is very easy for citizens of any of the four countries, as well as U.S. citizens and other eligible foreign nationals legally entering any of the four countries. Under the Central America-4 (CA-4) Border Control Agreement, citizens and visitors meeting the above requirements may cross land borders without completing entry and exit formalities at immigration checkpoints (USCS, 2007). Also, throughout Central America, inspections at land borders are generally limited to immigration and customs checks and do not include agricultural inspections (Caniz, 2008). Human movement across land borders in Central America is not limited to migrants and visitors from Central American countries. Starting in the 1980s, Central America became a geographic bridge to North America for migrants from South America seeking to enter the United States (Mahler and Ugrina, 2006). In terms of pest risk, this may mean that the flow of pest introductions due to human movement may follow a northern course, with pests from South America moving into Central America and North America and pests from Central America moving into North America.

Land borders in South America. Information on human movement across land borders in South America is scarce. Venezuela and Guyana have 743 km of shared border (CIA, 2008), yet there are no official border crossings between the two countries (Kuiper, 2005). Movement of people across the mountainous border is unimpeded. One known crossing point is near Eteringbang, on the junction of the Cuyuni River (Kuiper, 2005). The movement of people across the border and lack of inspection checkpoints likely results in an exchange of plants and plant products between the two countries.

The same is the case for the other borders that are relevant in the context of this analysis: between Guyana and Suriname (600 km), Suriname and French Guiana (510 km), Suriname and Brazil (593 km), and Guyana and Brazil (1,606 km) (CIA, 2008).

Pathway: Ferries

Travel by ferry is common between some countries or islands of the GCR. The ferry Caribbean Express carried 145,000 passengers, 16,000 vehicles and 13,000 containers between Puerto Rico and the Dominican Republic in 2006 (Dominican Today, 2007). In Puerto Rico, seven CBP staff inspect all luggage, vehicles, and containers coming off the ferry, as well as part of the ship's interior. In the past, an agricultural sniffing dog was available to help with the inspections, but presently no dogs are being used. According to officers in Puerto Rico, ferry inspection procedures on the Dominican Republic side are more lenient, and the ferry's garbage is usually disposed of in the Dominican Republic because of less stringent regulations (Bertone and Meissner, 2008a). In April of 2007, various groups of the U.S. government joined forces in a blitz operation targeting Caribbean Express (Caribbean Risk Assessment Group, 2008). A total of 2,071 passengers and 198 personal vehicles were inspected over the course of 3 days, resulting in 68 plant QM and 7 pest interceptions. Assuming that the inspections detected every QM and pest present, this would translate into about 5,000 plant QMs and 500 pests per year arriving in Puerto Rico via Caribbean Express (not counting the cargo containers being transported on the ferry). Only a fraction of these pests would be intercepted by routine agricultural inspections. What percentage of these pests would be exotic to Puerto Rico is difficult to estimate. The pests intercepted during the blitz were identified as: *Planococcus citri*, *Dysmicoccus brevipes*, *Cucujidae* sp., *Anastrepha* sp., and *Melanagromyza* sp., only the latter two of which are considered actionable by the USDA. However, a number of exotic pests established in Puerto Rico are believed to have originated in the Dominican Republic (Caribbean Risk Assessment Group, 2008), and almost any pest may potentially be carried by ferry passengers. This pathway should thus be considered high risk, a conclusion which also reached by the Caribbean Risk Assessment Group.

There is also a regular ferry service between Belize and both Honduras and Guatemala (Travour.com, 2008). Ferries and high-speed catamarans are an important means of transportation between Martinique, St. Lucia, Barbados, Dominica, St. Vincent, and Guadeloupe; and there is potential for movement of plant products via this pathway. Catamaran passenger baggage is randomly selected for agricultural inspection twice a month (Ferguson and Schwartzburg, 2008).
A twice-daily ferry operates between the islands of Trinidad and Tobago. Given that they are traveling within the country, the passengers of this ferry are not subject to agricultural inspection.

Summary

Pest interception data related to human movement into or within the GCR is scarce; however, it is obvious that the number of travelers is immense. Most travelers arrive by air, but small vessels and cruise ships also carry large numbers of people. Movement across land borders in the GCR is not well-documented and is often overlooked; however, the associated pest risk may be considerable. The same is true for movement of yachts and other small vessels. For all modes of travel the level of phytosanitary inspection is generally insufficient to mitigate pest risk.

Recommendations

- **Post signs at marinas to educate visitors about the potential consequences of transporting exotic pest species on their vessels.**

- **Increase presence and visibility of inspectors** at marinas, mainly as a deterrent measure. Publicize interceptions as a warning to potential violators.

- **Post signs at eco-tourism sites** describing acceptable behavior while visiting the site. Visitors should be instructed to remain on marked paths and to neither bring into nor take out of the area any plants, plant parts, or animals.

- **Instruct visitors to clean shoes and clothing when entering or leaving a natural or agricultural area.** Visitors should remove soil and plant seeds from shoes and clothing and inspect cuffs and Velcro® closures. (Where appropriate, consider the use of water hoses, disinfectant foot baths, metal grates in ground for cleaning shoes, *etc.*).

- ❖ **Work with tour-guides and other staff at natural or agricultural areas to educate visitors on the potential environmental and economic effects of exotic species introduction.** For example, visitors to the El Yunque rainforest in San Juan are educated on environmental considerations prior to taking a walking expedition (Johnson, 2006).

- ❖ **Educate international air travelers prior to departure and deplaning about the potential consequences (economic, environmental, personal) of transporting agricultural products.** This could be achieved by on-flight announcements, informational brochures, or on-flight or pre-flight educational videos.

- **Raise money by providing products such as postcards, calendars, or souvenirs to visitors who give a donation** (Johnson, 2006). Use the money towards the prevention of exotic pest introductions. The products themselves can be educational by providing information on exotic pests of concern, dispersal mechanisms, and possible preventative actions.

- **Implement a user fee system for eco-tourist destinations.** Funds raised through ecotourism should go to exotic species prevention and management (Hypolite *et al.*, 2002).

- **Carry out biodiversity impact studies for ecotourism sites** to anticipate environmental and economic impacts of exotic species introduction.

- **Limit access to very sensitive sites** by restricting the number of visitors, access for vehicles, density of roads and trails, availability of accomodations, *etc.*

Chapter 2: Airline Passenger Baggage

Introduction

During the 20th century, air travel became the most important means of international people movement. On the Caribbean islands alone, there are over 50 airports (James, 2008), and the majority of all visitors to the islands—both from within and outside of the Caribbean—arrive by air (UNWTO, 2006).

International air travel has long been considered a significant means of moving pest species (NRC, 2002, Liebhold *et al.*, 2006). For example, Laird (1951) pointed out that aircraft are a pathway for insect introductions. Evans *et al.* (1963) found significant numbers of mosquitoes and other arthropods in both baggage compartments and passenger cabins of international aircraft. Russell (1987) determined that insects in the wheel bays of a Boeing 747 aircraft were likely to survive international flights of several hours' duration. Takahashi (1984) reported finds of insect vectors of human diseases in airplane cabins, and Takeishi (1992) found 5% of the fresh fruits carried illegally by airplane passengers from Thailand to Japan to be infested with fruit flies. Liebhold *et al.* (2006) suggested that fruit in airline passenger baggage may play an important role in introducing exotic pest species into the United States. Brodel (2003) pointed out that of 21 insect species that were found to have established in Florida between 1997 and 1998, only five were intercepted by PPQ prior to their establishment; four of them were intercepted on baggage (among other pathways).

The objectives of our study were to: a) use data collected by the U.S. federal government to estimate plant quarantine material (QM) approach rates (the percentage of sampling units containing QMs) and the annual number of plant QMs entering the United States in airline passenger baggage; b) discuss how plant QM approach rates relate to pest risk; and c) to explore how this data may be applicable to other countries of the Greater Caribbean Region (GCR). We hope that the thoughts outlined in this chapter may lead to more research and discussion and will provide a basis for coordinated decision-making towards phytosanitary improvements related to airline passengers.

Materials and Methods

We used Agricultural Quarantine Inspection Monitoring (AQIM) data collected by the U.S. Department of Homeland Security (DHS) Customs and Border Protection (CBP) branch to estimate approach rates of plant QMs associated with international airline passenger baggage arriving in the United States. Plant QMs are any plants or plant parts that are prohibited from entering the United States. This prohibition is in most cases based on a determination that the plant material presents a significant risk of harboring exotic pest organisms. If sampling procedures are followed correctly, AQIM data is collected through a very detailed inspection of randomly selected sampling units. This means that, in contrast to regular (non-AQIM) passenger inspections at airports, which are targeted at high-risk groups, AQIM data is unbiased. Data collected through AQIM activities is therefore suitable for risk quantification. AQIM data on airline passengers contains information about passenger origin, number of people traveling together, date of travel, airport of inspection, airline, numbers and types of QMs found, and a host of other data elements. However, AQIM data does not include useable information on pest interceptions. Details on AQIM data sets and sampling protocols are documented in the USDA AQIM Handbook (USDA-APHIS-PPQ, 2008b).

The AQIM data used in this study were collected at 30 U.S. airports in 21 U.S. states between January 1, 2005 and August 22, 2007. The plant QM approach rate is defined as the percentage of sampling units in which plant QMs are found. The sampling unit in this case was the group of airline passengers (one to many individuals) traveling together under one U.S. customs declaration. To express the level of uncertainty associated with QM approach rate estimates, estimates are presented as 95% binomial confidence intervals (*i.e.*, the limits within which the actual approach rates lie with 95% certainty) (Steel *et al.*, 1997). For small sample sizes, the uncertainty associated with the approach rate estimate is large (*i.e.*, the binomial confidence intervals become wide). A sample size of 30 is considered the minimum meaningful sample size for estimating proportions (Cochran, 1977); treatment groups with sample sizes under 30 were therefore not considered for this analysis.

We calculated approach rates by country of passenger origin and by reason for travel using the RELIABILITY, MEANS, TABULATE, and SQL procedures in SAS® 9.1.3 (SAS Institute, 2007). To estimate the annual number of passenger groups entering the United States with plant QMs, approach rates were then multiplied by the average number of passenger groups that entered during 2006. This last number was calculated by dividing the annual number of visitors (obtained from the U.S. Department of Commerce) during 2006 by the average passenger group size as indicated by AQIM data. This AQIM-based estimate of the number of QMs arriving annually in the United States was then compared to the number of QMs that were actually intercepted during routine (non-AQIM) passenger inspections at airports in 2006 (USDA, 2008f). The ratio of the number actually intercepted to the estimated number to have entered is used as a measure of the interception efficiency of routine air baggage inspections.

Information on pest interceptions was obtained from the USDA-APHIS-PPQ PestID database, which contains records of all pest interceptions made by PPQ or CBP at U.S. ports of entry since 1985 (USDA, 2008d). For this analysis, a pest is defined as a species of arthropod, mollusk, weed, nematode, or plant pathogen that is injurious to plants or plant products.

Results and Discussion

Risk to the United States

Because AQIM data are collected at U.S. ports of entry, they primarily are a reflection of the phytosanitary risk faced by the United States. Thus, risk is discussed from the standpoint of the United States first; the applicability of the data to other countries of the GCR is explored later.

In total, almost 52 million international visitors came to the United States in 2006 (OTTI, 2007b). With an average group size of 1.4 (AQIM data), this is equivalent to 37 million visitor groups. Using AQIM data, the overall plant QM approach rate was calculated at 3.75% (95% binomial confidence interval: 3.70-3.81%). Given 37 million visitor groups, an estimated 1.4 million visitor groups arrive with plant QMs in their luggage at U.S. airports per year (**Table 2.1**). Each group carried on average 1.2 different plant QM types (*e.g.*, apples, oranges, mangoes, *etc.*), leading us to an estimate of 1.7 million instances of QM arrivals (1.4 million visitor groups with QMs multiplied by 1.2 QM types per group) during 2006. Each of these instances involved one or more individual QM units (*e.g.*, five apples).

The USDA Work Accomplishment Data System (WADS) (USDA, 2008f) records, among other data elements, the monthly total number of QM interceptions by U.S. port of entry; each QM type found per inspection is counted as one interception (*e.g.*, if five oranges, three apples, and 20 mangoes are found on one sampling unit, this would be recorded as three interceptions). For the 2006 calendar year, a total of 407,000 plant QM interceptions were recorded in WADS. Comparing this to the AQIM-based estimate of 1.7 million instances of QM arrivals, we conclude that around 24% of all arriving plant QMs were intercepted by CBP, leaving about 1.3 million plant QMs that entered the United States undetected in 2006. This interception efficiency is similar to those estimated in other studies, *e.g.*, 31-42% for international airline passenger baggage into Hawaii (Culliney *et al.*, 2007), 8% for personal vehicles entering across the Mexican border (Meissner *et al.*, 2003), and 27% for pedestrians entering across the Mexican border (Meissner *et al.*, 2003).

What does this mean in terms of *pest* risk? Not all QMs intercepted will be infested or are even likely to be infested with pests. For example, bananas—a QM frequently intercepted on airline passengers—are generally considered a low phytosanitary risk to the United States and are, in cargo shipments, permissible from most countries. However, when found on airline passengers, the origin of the fruit cannot be verified anymore, and the fruit may therefore be seized, adding a QM interception to the database.

Translating plant QM approach rate estimates into pest approach rate estimates is not trivial. AQIM data does not provide reliable information on the frequency of pests in airline passenger baggage because, in contradiction to the AQIM sampling guidelines (USDA-APHIS-PPQ, 2008b), searching for pests is rarely performed during AQIM data collection (Pasek, 2007).

It is safe to assume that the pest detection efficiency of routine passenger inspections is lower than the QM interception efficiency, because there is a considerable chance that pests may not be detected on intercepted plant QMs. Pests may go undetected because they are minute or hidden (*e.g.*, mites, internal feeders). Due to time pressure, U.S. inspecting officers frequently discard intercepted plant QMs without looking for pests. For procedural reasons, pest categories such as viruses, bacteria, phytoplasmas, and nematodes are almost never identified and recorded. If we assume that during port inspections one of every 10 infested plant QMs is identified as being infested (Rogers, 2008), given our estimate that 24% of arriving QMs are intercepted, only 2.4% of all *infested* QMs arriving in air passenger baggage are intercepted *and* identified as infested. These resulting pest finds are recorded in the PPQ PestID database (USDA, 2008d). For the calendar year 2006, 12,282 interceptions of reportable pests in international airline passenger baggage, involving at least 1,500 pest species of quarantine significance to the United States, were recorded in PestID. If that number was 2.4% of what actually arrived, then over half a million instances of reportable pest arrivals, each potentially involving several pest organisms or reproductive units, may have occurred in 2006. With a 24% QM interception efficiency, over 375,000 of these pest arrivals escaped detection by baggage inspections. (We are using the QM interception efficiency as opposed to pest detection efficiency here because any associated pests would be destroyed together with the intercepted QMs. Therefore, the risk associated with these pests is mitigated.)

By Reason for Travel

The following reasons for travel were compared in terms of plant QM approach rates: Business/Work, Visit Family, Visit Friends, Military, Tourist, Uniformed Crew, and Other. For each of these categories, QM approach rates were significantly different from zero. The category “Visit Family” was associated with the highest QM approach rates (**Figure 2.1**) and was statistically different from all other categories. This finding corroborates the intuitive assumption that international passengers visiting family are more likely than tourists or business travelers to carry plant QMs because they tend to bring ethnic food items (fresh fruits, vegetables, or plant materials) as gifts. We assume that it does not matter whether the traveler is a foreign national visiting a relative in the United States or is a foreign-born U.S. resident returning from a family visit in another country. In the former scenario, the traveler would bring ethnic food items as gifts to the family in the United States. In the latter case, the traveler would return to United States with similar items from his/her family. The second-highest approach rates were associated with the category “Visit Friends,” which was also statistically different from all other categories. The QM approach rate of the category “Tourism” was significantly lower than those of “Visit Family” and “Visit Friends”, but significantly higher than those of the categories “Business/Work,” “Military,” and “Uniformed Crew”.

The only information we have available to determine the percentage of visitors in each of the travel reason categories is AQIM data. Based on that (**Table 2.2**), approximately one-third of the travelers were tourists, one-third were visiting family, and about one-fifth were on work- or business-related travel. The remaining categories accounted for only a small percentage of the visitors.

Not all QMs represent the same level of risk. Across all travel reasons, the 10 most commonly intercepted QMs were (in decreasing order of interception frequency): apples, mangoes, oranges, bananas, seeds, pears, unspecified fresh fruit, plums, yams, and plants. Apples, oranges, and bananas are fruits that are often packed by travelers for consumption along the way as they are popular, easy to carry, and easy to eat. These items present a low risk for introduction of exotic plant pests. In contrast, seeds, potato and yam tubers, flower bulbs, and other items suitable for propagation are high-risk QMs. For more information on the risk of the propagative material pathway, see Chapter 8.

The diversity of QM was higher for travelers visiting family than for tourists. More than a hundred QM types were intercepted on travelers visiting family but not on tourists, and only 17 QM types were intercepted on tourists but not on travelers visiting family.

By Origin

A total of 237 countries of origin were represented in the AQIM data set. Of these, 164 had sample sizes of 30 or higher and are included in the following analysis. Twenty-nine countries of origin with sample sizes of 30 or higher are located in the GCR. Plant QM approach rate estimates for the countries of origin range between zero (lowest lower CL) and 62% (highest upper CL). **Figure 2.2** shows the 25 countries with the highest plant QM approach rates. In some cases, the 95% binomial confidence intervals were large, due to relatively small sample sizes. For Angola, Botswana, French Guyana, Georgia, Luxembourg, Mongolia, Oman, Samoa, and Sudan, binomial confidence intervals include zero (*i.e.*, the plant QM approach rates are not significantly different from zero). Out of the 25 countries with the highest approach rates, 10 were Caribbean countries: Haiti (21%), Bonaire (18%), St. Vincent (13%), Grenada (13%), Guadeloupe (12%), St. Lucia (11%), Antigua (9%), Bahamas (9%), Jamaica (8%), and Dominica (8%). The plant QM approach rates for all available Caribbean countries of origin are depicted in **Figure 2.3**.

The annual number of plant QMs entering the United States from each country of origin is equal to the plant QM approach rate for the country of origin multiplied by the average number of QMs per declaration (1.2), multiplied by the annual number of visitor groups arriving to the United States by air from that country. Canada is the origin of the highest number of air travelers to the United States, over 5.5 million visitor groups annually. The estimated plant QM approach rate for Canada is 4.7% (95% CL: 3.5-6.2%), which is significantly lower than the rates of the following, relatively small, number of countries: Trinidad, Antigua, Syria, Peru, Jamaica, St. Vincent, Ecuador, St. Lucia, Bolivia, Grenada, Bangladesh, Bonaire, Iran, Haiti, and Palau. Multiplied by the large number of visitors arriving from Canada, this QM approach rate translated into by far the highest number of plant QMs entering the United States from any country (**Figure 2.4**). Approximately 135,000-240,000 plant QMs from Canada and over 30,000 each from Japan and Germany are estimated to enter the United States per year. Other countries that almost certainly supply more than 10,000 plant QMs per year are: Argentina, Bolivia, Ecuador, France, India, Israel, Italy, Mexico, and the Netherlands. A large number of countries are the source of smaller numbers of QMs. The quarantine materials intercepted from Canada, Japan, and Germany were largely apples, bananas, oranges and some other common fruits, such as grapes. However, among the interceptions from Germany were also bulbs, seeds, wood, pine cones, soil, and plants. From Japan, seeds, bulbs, and leaves were also intercepted.

Risk to Other Caribbean Nations

Although AQIM data is collected at U.S. ports of entry, the data is likely to be valuable to other countries in the GCR, given that they receive visitors from many of the same countries of origin. With well over 30 million[9] airline passengers (20 million passenger groups), mostly tourists, visiting the GCR annually and a plant QM approach rate of perhaps 5-10%, over 1 million plant QMs may be entering the GCR in airline passenger baggage every year.
However, what the United States considers a QM would not necessarily be a QM to other countries. Secondly, specific food items and propagative material carried by people visiting friends and family will vary somewhat between countries. The United States is an immigration country; thus, travelers to the United States in the "visit friends" and "visit family" categories would likely be either persons from foreign countries visiting relatives who live in the United States, or U.S. residents of foreign origin returning from family/friend visits in their home country. In either case, they are likely to bring QMs such as typical fruits and vegetables (possibly home-grown) from a foreign country into the United States. On the other hand, most of the other countries in the GCR are sources of emigration to the United States, Canada, and the European Union (United Nations, 2005). Thus, travelers in the visit family/friends categories who enter these Caribbean countries would not be as likely to be bringing in QMs; rather, they may be expected to be bringing electronics, clothing, and other types of gifts that are less expensive or more easily available in the immigration countries.

Country of destination is presumably a less important factor for travelers in the "tourist" category, as it may be assumed that a tourist brings along similar kinds of QMs regardless of his/her destination. One third of all travelers to the GCR cited tourism as their reason for travel (**Table 2.2**), a higher percentage than for any of the other travel reasons. Approximately 85% of the tourists originated in Europe, and North America (The Royal Geographical Society, 2004). In the following section, we provide approach rate data by country of origin for the tourist category only.

Tourists Only

A total of 215 different countries were represented in the data set; of these, 110 had sample sizes of 30 or higher for the tourist category and are included in the following analysis. Twenty-seven countries of origin with sample sizes of 30 or higher are located in the GCR. QM approach rate estimates for the countries of origin range between zero and 40%. In some cases, the 95% binomial confidence intervals are large, due to relatively small sample sizes. For Ethiopia, Lebanon, Saudi Arabia, Pakistan, Cuba, Nepal, and Zambia, binomial confidence intervals include zero (*i.e.*, the approach rates are not significantly different from zero). Out of the 10 countries with the highest approach rates, seven are located in the GCR: Bonaire (20%), Guyana (20%), Guadeloupe (12%), Grenada (11%), St. Vincent (10%), British Virgin Islands (9%), St. Kitts and Nevis (9%); the others were Malta (10%), Estonia (9%), and Iran (9%) (**Figure 2.6**). Canada, France, Germany, and the United Kingdom are among the countries where most of the

[9] This estimate is based on data from a large number of official databases and country reports

visitors to the Caribbean originate (The Royal Geographical Society, 2004). The approach rates associated with these countries of origin are 8%, 4%, 5%, and 4%, respectively.

Conclusions

International airline passenger baggage may be an important pathway for exotic species movement. For most countries, the pest risk is not comparable to that posed by some other pathways; however, the risk associated with passenger baggage is not negligible.

In the case of the United States, the highest risk from international airline passenger baggage can be attributed to travelers who are visiting family or friends (about one-third of the travelers). In contrast, tourists or business travelers do not represent a great risk to the United States. For most other countries in the GCR, the majority of all visitors are tourists, and even visitors in the "visit family" and "visit friends" categories may not present a high level of risk. However, as this analysis has shown, there is a large amount of plant QMs moving in international airline passenger baggage. Since the worldwide air transportation network quickly connects geographically distant, but climatically similar regions (Tatem and Hay, 2007), the plant QMs that do move may very well carry exotic plant pests that can easily adapt to the new environment. Thus, it is important to consider mitigation options for this pathway.

Given the relatively low interception efficiency of port inspections, it is unlikely that the existing pest risk associated with the airline passenger pathways can be mitigated effectively by inspection alone. It may be possible to improve inspection efficiency to some degree by increasing the numbers of inspectors and by providing them with more adequate inspection equipment and facilities. However, additional ways of preventing exotic species introduction will have to be pursued.

Recommendations

- **Educate international air travelers prior to departure and deplaning about the potential consequences (economic, environmental, personal) of transporting agricultural products.** This could be achieved by on-flight announcements, informational brochures, or on-flight or pre-flight educational videos.

- **Remind plane passengers to consume or discard prohibited materials during the flight.**
  - Announcements by the flight crew could remind travelers that they are not allowed to take certain materials into the destination countries.
  - When collecting trash before landing, the flight crew may specifically ask for fruits, vegetables, seeds, plants, meats, or other prohibited items.

- **Expand the use of detector dogs for baggage inspection.** This is a less intrusive and faster method than opening of the luggage by human inspectors.

- **Invest in research on inspection technology (***e.g.*, robotic nose**,** x-ray technology, *etc.***)**

- **Develop targeting strategies for inspection of airline passenger baggage.** Possible targeting criteria include origin of passenger, seasonality, and holidays. In order for this to be possible, a systematic data collection program has to be implemented.

Chapter 3: International Mail

Definitions

The following definitions apply to mail-related terminology used throughout this chapter:

Mail: Any material, such as letters, information, tangible objects, written documents, remittances, parcels, or packages, sent or carried in the postal service to domestic or international destinations.

Postal Service: An organization which handles, sorts, and transports mail.

Public Postal Service: A government or ministerial department or agency, sometimes semi-privately operated or operated as a public corporation which handles the transmission of mail. It also may be referred to as a National Postal Service. These public or national systems may also offer overnight or express mail services.

Private Postal Service: A private company that handles, sorts, and transports mail, primarily in the form of parcels. The emphasis in most of these businesses is on rapid overnight or express mail movement. Some well-known private postal services include Airborne Express, DHL Worldwide Express, Federal Express, and United Parcel Service (UPS), among other companies.

Approach rate: The percentage of randomly inspected packages that contained what the search was targeting (*e.g.*, plant materials). The approach rate is usually given as a percentage with a 95% binomial confidence limit. This confidence limit is the limit within which we can say the true approach rate falls with 95% confidence.

Introduction

Among the many potential pathways for pest movement, mail, carried by both public and private postal services, is often overlooked.

Like people everywhere, inhabitants of the Greater Caribbean Region (GCR) use public and private postal services to send and receive items from friends and family abroad and to purchase mail-order goods. Increasing opportunities for online shopping have spurred a demand for more packages to be delivered by mail in recent years (Vargas, 2004, Thomson Reuters, 2008). Private postal services such as FedEx, UPS, or DHL have experienced growth due to the active parcel service market (Morlok *et al.*, 2000).

Almost anything can be sent by mail—either legally or illegally—and controlling mail contents presents an immense challenge to any country. Various data collection efforts in the United States have shown that live plants and plant pests are being shipped by mail, often in connection with a mail-order purchase (Keller and Lodge, 2007, Zhuikov, 2008). For example, plant seeds purchased online, including anthurium, tropical jackfruit, American oil palm, papaya, oleander, and sour orange were intercepted in separate foreign mail shipments from Belize to southern Florida. The USDA also intercepted citrus cuttings infected with citrus canker (Hoffman, 2004).

It seems likely that similar avenues of trade in plants or plant pests occur throughout the GCR, placing the region at risk of pest introductions. The objective of this chapter was to gather and interpret available information to evaluate the risk of pest movement associated with the mail pathway. Specifically, we examine the types of quarantine materials (QMs) transported by mail and provide recommendations for improved safeguarding in connection with the mail pathway.

Discussion

During Agricultural Quarantine Inspection Monitoring (USDA, 2008f) carried out by the U.S. Department of Homeland Security from 2005 through 2007 at 11 U.S. ports of entry, a large variety of plant materials and a few insect pests were intercepted in both public and private international mail entering the United States (**Table 3.1**). These items included fresh and dried fruits and vegetables, leaves, spices, whole plants, and cut flowers. Some of the intercepted items were considered items of U.S. quarantine significance. The remaining items were released after inspection because they were not considered to present a pest risk to the United States; however, if entering other countries within the GCR, some of the same items may very well pose a phytosanitary threat.

The proportion of the various item types intercepted was very similar in public compared to private mail of worldwide origin (**Table 3.2**). In both cases, seeds and pods, potentially very high-risk items, were the most frequently shipped category. In public mail, the category "herbs, spices, and flowers, dried or processed" was shipped more frequently than in private mail. Conversely, in private mail, wood items were represented more frequently. When looking at mail of GCR origin only, again, wood items were much more likely to be found in private compared to public mail. Also, coffee or tea was found in 30% of the private mail packages versus only 9% of the public mail packages. We suspect that people choose between public versus private mail based, in part, on the weight and value of the items shipped. Because private mail carriers are generally considered more reliable and offer better tracking of the shipment, higher-value items would be more likely to be shipped by private mail.

A total of 76,132 public mail packages were selected randomly for inspection and opened. Of these, 855 contained plant quarantine materials or pests, representing an approach rate of 1.15% (95% binomial confidence interval: 1.1-1.2%) (**Table 3.3**).

In the case of private mail, a total of 18,455 packages were opened, leading to the interception of 1,042 plant materials/plant pests, only 24 of which were considered U.S. quarantine materials. In 15 of the cases, insects were found, 12 of them live butterflies, though not agricultural pest species. The approach rates for plant materials/plant pests and plant materials/plant pests of U.S. quarantine significance were 5.6% (95% binomial confidence interval: 5.3-6.0%) and 0.13% (95% binomial confidence interval: 0.08-0.19%), respectively (**Table 3.3**).

It is curious that in private mail, the approach rate for plant materials/plant pests was twice as high as for public mail, but the approach rate for plant material/plant pest items of U.S. quarantine significance was 10 times as high in public compared to private mail. One possible explanation for this may be that commercially produced, higher-priced items, which are more likely to be free of pests may also be more likely to be sent by private mail, whereas home-grown items, which are more likely to be infested/infected with pests may be more likely to be sent by public mail, which costs less. However, this is mere speculation.

When looking only at packages originating in countries of the GCR (excluding the United States), of 2,414 public mail packages that were inspected, 77 contained plant materials/plant pests, and 18 contained plant materials/plant pests of U.S. quarantine significance. The approach rates for plant materials/plant pests and plant materials/plant pests of U.S. quarantine significance were 3.2% (95% binomial confidence interval: 2.5-4.0%) and 0.8% (95% binomial confidence interval: 0.4-1.2%), respectively (**Table 3.3**).

Of 374 private mail packages originating in the GCR that were inspected, six contained plant materials/plant pests of U.S. quarantine significance, representing an approach rate of 1.6 (95% binomial confidence interval: 0.6-3.6%) (**Table 3.3**).

The number of packages arriving with plant materials/plant pests is the approach rate multiplied by the total number of packages arriving. We estimate countries of the GCR receive approximately half a million packages in the public mail per year (Universal Postal Union, 2008). (This estimate does not include those Caribbean countries which did not provide postal statistics, and the United States, for which we did not have state-level mail statistics.) **Table 3.4** lists the number of packages arriving in public mail by country and provides an estimate of the total number of packages arriving with plant materials/plant pests based on the approach rate of 2.7% (95% binomial confidence interval: 2.6-2.8%) calculated above (**Table 3.3**). We estimated that the GCR (excluding the United States) may annually receive between 13,876 and 14,943 mail packages containing plant materials or plant pests, with up to 4,000 of these being propagative materials. Whether these plant materials/plant pests constitute a threat would vary from case to case, depending on the materials and the country of destination. It also needs to be kept in mind that the postal statistics provided pertains to public mail only. Market studies suggest that only 10% of parcel mail is moved by public postal services in the Caribbean region, while 80% of parcels are moved by private postal services such as FedEx, UPS, and DHL (Universal Postal Union, 2007). Furthermore, the statistics pertain to packages only. While most materials we are concerned about would have to be sent in packages, some may also be mailed as letters. This is especially a concern in the case of seeds.

While AQIM data is the most statistically useful data for risk estimates, there are various other data available that may provide some additional insights.

Routine port-of-entry inspection of private mail in Miami was started in 2000 and is now a component of the Foreign Mail Center Work Unit. Three inspectors and a detector dog are dedicated to this activity. Packages are selected for inspection based on the manifest and certain risk factors. Packages where no products of agricultural significance are listed on the manifest are thus likely to escape inspection. During the fiscal year 2007 about 1.5 million packages were received; a little over 68,000 of them were scanned, and 4,280 of these were opened. A total of 4,780 kg of plant QM, 29 shipments with non-compliant WPM, and 33 restricted soil shipments were intercepted (Lemay *et al.*, 2008). No pest interceptions were recorded for this time period, but we do not know to what degree intercepted QMs were inspected for pests. In comparison, during the fiscal year 2008 only 1,622 private mail packages were opened, resulting in 106 plant QM interceptions (USDA, 2008f). Fourteen pest interceptions are recorded, seven of which were from the GCR. Among the intercepted pests are a number of insects capable of flight imported on cut flowers (**Table 3.5**), for which the likelihood of escaping into the environment is relatively high.

Routine port-of-entry inspections of public mail in Miami resulted in 132 plant QM interceptions from 1,483 packages opened during the fiscal year 2008 (USDA, 2008f). Forty-four pests were intercepted, 11 of them from the GCR (**Table 3.6**).

In a collaborative data collection effort in Puerto Rico of the U.S. Department of Homeland Security-Customs and Border Protection (DHS-CBP) and the USDA Smuggling Interdiction and Trade Compliance (SITC), inspectors x-rayed 19,096 USPS packages sent from the U.S. Virgin Islands to Puerto Rico, ultimately destined for the United States mainland (USDA-APHIS-SITC, 2006), between November and December, 2006. Based on the x-ray screening, 2,525 packages were referred to inspection, which resulted in the detection of 579 packages containing agriculture-related items. The following types of items were found: 30% seeds, many of weeds or quarantine plants; 16% fresh fruit, such as apples, oranges, mangoes, olives, pears, peaches, bananas, limes, loquats, bitter melons, avocados, berries, and tomatoes; 9% leaves, presumably for tea or other food ingredients; 8% live plants, presumably for propagation, of which 20% were weeds and 8% were bulbs for planting; and 29% other items (roots, unknown plants, *etc.*). Of the packages from which items were intercepted, 46 packages (0.002% of all packages screened) contained plant materials or plant pests of U.S. quarantine significance.

Similar data collection efforts of DHS-CBP and SITC targeted mail of Chinese origin arriving in New Jersey during the time preceding the Chinese New Year (CBP and SITC, 2008). Most prohibited items found during these inspections were destined for personal consumption, but a few items were meant for commerce, such as restaurant supplies. In 2007, 44 of 2,847 (1.5%) inspected packages contained plant materials/plant pests of U.S. quarantine significance; and in 2008, 48 of 7,188 (0.7%) inspected packages contained plant materials/plant pests of U.S. quarantine significance. These approach rates are within the same range as the ones derived through AQIM data collection. Prohibited plant-related items in mail in 2007 and 2008 included: seeds, pods, entire plants, and other propagative materials (seed millet, yams, unspecified plants and seeds for planting, citrus seeds, cucurbit seeds, roots, vegetable seeds, fava beans, coconut, and wild rice); fresh fruits (plums, stone fruit, citrus, jujube, dates, Szechuan pepper (Rutaceae), tomatoes, litchi, and unspecified fruits); nuts which may also be propagative (chestnuts, walnuts, fresh peanuts, acorns, and tree nuts); other fresh plant materials (unspecified vines, leaves, grass, curry leaves, branches with leaves, fresh herbs); wood, wood chips, and bark; processed products (corn products, citrus peel); soil; and insect larvae in wooden crates.

SITC data collection at JFK International Airport in New York targeted private mail (*e.g.*, DHL, FedEx, and TNT) from India and Southeast Asia (USDA-APHIS-SITC, 2007). Canine teams were used to screen shipments. Of the 3,682 items inspected, only two packages were found with plant QMs, one containing limes and the other tubers of *Amorphophallus* sp. (propagative material).

SITC international mail interceptions were reported from the San Francisco International Mail Center (SFIMC) Mail Interception Notice (MIN) database which contains over 11,000 records from 2000 to 2005 (USDA-APHIS-SITC, 2005). There were records of 189 international packages containing a total of 199 different plant materials/plant pests of U.S. quarantine significance (**Table 3.7**). While this data set contains no interceptions from the GCR, it provides information about the kinds of prohibited items likely to move in international mail. Seeds were intercepted most frequently (56 interceptions) and included primarily vegetable and grass seeds. Fresh fruits were found 56 times, including Chinese olives, olive, citrus, loquats, persimmons, mango, Szechuan pepper (Rutaceae), pears, and other tropical fruit. Propagative materials other than seeds (tubers, seedlings, whole plants) were the next most commonly found items, but included a broad array of plants, *Brassica* sp., noxious weeds, sugarcane, grasses, orchids, flowers, sweet potatoes, bulbs, and bamboo (32 items). Propagative materials, including seeds, were overall the most commonly intercepted prohibited agricultural items, emphasizing that mail is an especially important pathway for propagative materials.

Items moved in mail worldwide that may present clear threats to the Greater Caribbean are those related to the major crop, landscape, or forest plants in the region. For example packages carrying any palm products (fruit, plants, leaves, shoots, seeds, coconuts, untreated handicrafts (wooden or fronds)) would present a risk of introducing palm pests, such as the recently introduced red palm mite, or the exotic phytoplasma palm lethal yellowing, to a region where palms of various kinds are extremely important in the landscape, tourism, and agriculture. Sugarcane and bananas are also extremely important crops in the region, and importation of these plants or commodities increases risk of entry of new pests, like exotic sugarcane pests or black Sigatoka of banana which are still absent in some areas of the Caribbean. Importation of seeds, entire plants, or roots and tubers (cassava, dasheen, sweet potatoes, yams) that can be used for propagation present the risk of introducing pests together with a suitable host plant and of becoming invasive plants (Kairo *et al.*, 2003). Movement of unroasted coffee beans within the GCR could exacerbate problems with already established pests such as the coffee berry borer, *Hypothenemus hampei* (Coleoptera: Curculionidae: Scolytinae) (Cruz and Segarra, 1996, Caribbean National Weekly News, 2007), or result in the establishment of new pests or pathogens.

Brodel (2003) reported that of 21 insect species that were found to have established in Florida between 1997 and 1998, only five were intercepted by USDA-APHIS-PPQ prior to their establishment; two of them were intercepted on mail.

To a large degree, the mailing of materials that present a phytosanitary risk is probably inadvertent, given that people are often unaware of regulations or do not understand why certain items are prohibited. When SITC tracked down a person who had made an on-line purchase of several giant African snails and walking stick insects from a seller in the United Kingdom, the customer, a high school biology teacher, stated that she was not aware of any risk associated with importing these organisms (USDA-APHIS-PPQ, 2008c). However, there are cases where prohibited items are clearly smuggled by mislabeling customs forms on packages. For example, 19 potted *Crocosmia* plants from the United Kingdom were detected in a package labeled as "cappucino machine and cups/saucers" and a subsequent investigation revealed additional smuggling activities by the same customer (USDA-APHIS-PPQ, 2008c). People regard the mail as private communication and do not expect scrutiny of the contents.

Available inspection technologies and methods are often not effective when used as the only method. For example, x-ray technology is not effective for detecting dry items such as twigs, leaves, or seeds, although it works well to detect items with high water content, such as fruit. Similarly, detector dogs can be very good at finding hidden items, but they detect only those materials for which they have been specifically trained, and they get tired after a certain amount of time. The performance of human inspectors, as well, is not always reliable and tends to vary considerably between individuals, time of day, and other factors.

The degree to which mail is inspected varies widely within the GCR. A few countries, such as Jamaica (Schwartzburg and Robertson, 2008), the Dominican Republic (personal comm. Colmar Serra), and Trinidad and Tobago (Bertone and Gutierrez, 2008) open and inspect virtually every package that arrives. Jamaica also scans all outgoing packages (Schwartzburg and Robertson, 2008). At the international mail facility in Miami, Florida the only packages opened are those that are suspect (based on x-ray or manual examination) or are considered high-risk based on certain criteria. X-ray machines and detector dogs are often used (USDA-APHIS-PPQ, 2008d). Martinique has lost the use of its mail sorting facility in Fort-de-France due to an earthquake in November of 2007. The current replacement facility is a semi-open warehouse with rolling carts for sorting packages. No x-ray machines are available for scanning packages (Ferguson and Schwartzburg, 2008). In most countries, many quarantine items undoubtedly pass through the mail without being intercepted. Mail from Puerto Rico and the U.S. Virgin Islands entering the United States is treated as domestic mail. Due to differences in CBP procedures, postal facility procedures, and local practices, methods of inspecting mail may vary from port to port. Search warrants are mandatory for opening domestic mail (USDA-APHIS-PPQ, 2008d), but are not necessary for international mail.

Compared to some other pathways like the commercial importation of agricultural cargo, and especially nursery stock, the mail pathway may pose a lesser phytosanitary risk. However, this determination is based on very limited data, and more research is needed to adequately determine the risk posed by the mail pathway. In the meantime, international mail is definitely not a pathway that should be ignored.

Recommendations

- **Post educational information at public and private mail facilities** to inform senders of the potential economic and environmental impact of exotic species introductions and to increase public awareness of phytosanitary regulations as they pertain to mail.

- **Conduct periodic data collection efforts ("blitzes") at mail facilities.** Carry out statistically-sound data collection to answer specific questions. Consider region-wide coordination and sharing of resources for carrying out blitzes. Share results region-wide.

- **Allow inspection of USPS first class mail in Puerto Rico before leaving to the United States.** The lack of authority to inspect first-class mail seriously undermines the quarantine process. Establish a PPQ working group to devise a program that will permit inspection of USPS first class mail in Puerto Rico before leaving to the United States. Current regulations (7CFR318.13 and 7CFR318.58) allow for such actions. Hawaii has developed a process for obtaining search warrants, allowing inspection of suspicious first-class packages destined to the mainland United States. A detector dog is used to establish probable cause.

- **Foster collaboration between customs officials, agricultural officials, mail facility staff, and any other groups involved in mail handling and inspection.**

- **Establish mail inspection systems** in countries where they do not yet exist. This is obviously a big and long-term undertaking that may not be immediately feasible everywhere.

- **Implement package tracking and tracing technology at mail facilities.** Improve public and private mail systems, in particular the ability to track and trace parcels.

- **Increase the man-hours spent inspecting mail packages** for quarantine materials, even if only periodically.

- **Use appropriate inspection technology** (*e.g.*, x-ray systems) at mail facilities.

- **Use detector dogs** at the mail facility.

- **Record data on pest interceptions in mail.** Collect and archive data on pest and quarantine material interceptions in mail. Ideally, the database or at least the format of the database should be region-wide.

- **Create a regional bulletin or newsletter to** share information about noteworthy pest interceptions in mail, mail inspection methodologies, relevant meetings, *etc.*

- **Conduct surveillance of commercial internet sites.** Quarantine materials (especially propagative materials) are being sold and often smuggled through mail order. USDA-SITC has attempted a surveillance initiative ("AIMS") and may be able to offer some insights.

- **Organize a regional mail handler's conference** as a formum for sharing information, ideas, strategies, technologies, *etc.* Hold mail inspector training meetings.

Chapter 4: Maritime Traffic

Introduction

In a region composed largely of island nations, maritime traffic obviously plays an important role in transportation and may thus also be expected to play an important role in the spread of exotic pests.

In the context of maritime traffic, there are several ways in which pests may be disseminated: with commodities (both agricultural and non-agricultural); as hitchhikers on the vessels and containers used for transport; and in the wood packaging material (WPM) accompanying the commodities.

The pest risk associated with both hitchhikers and WPM is discussed in detail in other chapters of this report.

The pest risks associated with commodities, while very possibly the most important threat, are extremely hard to characterize due to the immense number of different commodities arriving from all areas of the world, each likely to be associated with different pest species. Given that legally traded commodities already receive attention from importing countries, and given that a general process for commodity pest risk assessment is in place (IPPC, 2007) and must be commodity- and origin-specific to be meaningful, we will not focus on commodities in this chapter. Rather, we attempt here to give a general overview of maritime trade as it pertains to the Greater Caribbean Region (GCR), pointing out some issues of special concern and providing a general background to complement the information laid out in later chapters of this report. Specifically, we will discuss the importance of the GCR as a "crossroads" of international trade and the significance of undocumented "inter-island" trade.

Discussion

The GCR as a Crossroads of International Trade

The Caribbean Basin, bordered by 33 countries and located at the intersection of maritime trade routes between North and South America and between the Eastern and Western hemispheres, is an important location for facilitating world trade. By providing a connection between the Pacific and the Atlantic, the Panama Canal plays an important role in funneling maritime traffic through the Caribbean Sea.

Several maritime ports in the GCR are among the busiest ports in the world. The ports of San Juan, Puerto Rico; Freeport in the Bahamas; Kingston, Jamaica; Houston, Texas; Miami, Florida and Jacksonville, Florida in the United States; and Manzanillo and Coco Solo in Panama ranked among the top 100 ports worldwide for highest container traffic in 2005 (**Table 4.1**) (Degerlund, 2007). As countries (or territories), the Bahamas, Colombia, Costa Rica, Guatemala, Honduras, Jamaica, Panama, Puerto Rico, and Venezuela are among the top 60 worldwide in terms of container traffic handled (**Table 4.2**) (Degerlund, 2007).

The movement of cargo via maritime containers has steadily increased worldwide. Between 1995 and 2005, container traffic more than doubled in the GCR, reaching over 13 million TEUs[10] in 2005 (Ocean Shipping Consultants, 2006). Of these containers, about half were handled by ports of the Caribbean islands, 40% by the other ports in the GCR, and about 7% by ports on Central America's Pacific seaboard. **Figure 4.1** depicts container traffic between the Caribbean and other regions of the world, showing a general increase in the number of containers moving into and out of the GCR (Frankel, 2002). Several studies have predicted further positive growth (De Monie *et al.*, 1998, Ocean Shipping Consultants, 2006).

While the United States remains one of the main trading partners for the GCR, trade relations between the Caribbean and other regions of the world have expanded. The importance of Asian-Pacific imports grew for El Salvador, Panama, Barbados, and Trinidad and Tobago (Devlin *et al.*, 2008). The average annual growth rate for imports into Central America between 1990 and 2003 was approximately 37% for China, 10% for Korea, 7% for Japan, and 14% from Brunei, Indonesia, Malaysia, Philippines, Singapore, and Thailand combined (Devlin *et al.*, 2008). There has also been a 25% increase in value of imports from Asian-Pacific countries into Belize, Barbados, Dominica, Grenada, Jamaica, St. Lucia, Trinidad and Tobago, and the Dominican Republic. The majority of the exports from Asian-Pacific countries were manufactured goods. Trade between South America, Central America, and the Caribbean island countries also experienced growth between 1990 and 2003 (Devlin *et al.*, 2008).

Maritime ports in several Caribbean countries are integral to the trade network, not necessarily because they import or export a significant amount, but because they facilitate transshipment of commodities. Transshipment refers to a process whereby cargo enters a port from one country, is transferred to another conveyance, and then exits the port destined for another country. Transshipment is practiced for various logistic and economic reasons. Many Caribbean ports have neither the capability to receive large cargo vessels nor the trade volume that would make it economical for large vessels to call. Also, transshipment is strategic in improving delivery times of cargo, consolidating and deconsolidating cargo, enabling customization of cargo, rerouting of cargo, and circumventing various country regulations (Frankel, 2002). Thus, small feeder vessels pick up the cargo from a large ship at a hub port and distribute it from there ("hub-and-spoke schema") (De Monie *et al.*, 1998). These feeder vessels are often managed by local and regional carriers which transport a mix of containers and non-containerized goods, providing flexible service to small ports (McCalla *et al.*, 2005). Transshipment services are an important business to many Caribbean ports.

Transshipment traffic accounted for 40% of total container throughput in the GCR in 2005 and is expected to increase from around 8 million TEU in 2005 to 12 million TEU by 2010 (Ocean Shipping Consultants, 2006).

From a standpoint of pest risk, transshipment activity is important in that it leads to much larger numbers of vessels and cargo containers entering certain ports than would be the case for imports

[10] Twenty-foot equivalent unit (TEU) = the equivalent of a twenty-foot cargo container

alone. Even though the commodities themselves are not entering the country of the hub port, containers are unloaded from vessels and are often stored at the port for a certain amount of time. This provides external hitchhiker pests with an opportunity to either leave from or attach themselves to containers, or to move from one container to another. The risk is especially high if container yards are not paved and if vegetation is close by. Lights at container yards are bound to attract flying insects which may then end up on containers destined for a foreign country. Vessels being loaded and unloaded at the port may also be bringing in and taking out hitchhiker pests. The topic of hitchhiker pests is addressed in detail in a separate chapter of this report.

The following seven ports in the GCR have become major hubs for transshipment activity, forming what is referred to as the Caribbean Transshipment Triangle (Hoffmann, 2001, McCalla *et al.*, 2005):

Colon (including the ports of Manzanillo, Coco Solo, and Balboa), Panama services the Atlantic side of the Panama Canal. In 2002, over 75% of the traffic at this port was attributed to transshipments (McCalla *et al.*, 2005). Together with the port of Kingston, Jamaica, this port handles the majority of transshipment cargo related to Central America, especially since there is no dedicated shipping service between Central America and the countries of the Caribbean Community and Common Market (CARICOM, comprised of Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago) (Harding and Hoffmann, 2003, UNCTAD, 2005). Container traffic grew five-fold between 1994 and 2002, increasing from 255 thousand TEU to 1.45 million TEU (McCalla *et al.*, 2005).

Freeport, Bahamas. Located near the East-West trade routes, including those that pass through the Panama Canal between Europe and the east coast of the United States (Frankel, 2002, McCalla *et al.*, 2005), this port is almost exclusively a transshipment facility (De Monie *et al.*, 1998, McCalla *et al.*, 2005). The port transfers containers between mega container ships to Panamax container ships (the largest vessel that can pass through the Panama Canal) (Frankel, 2002). The port also handles cargo passing along the Central and South American trade routes (Frankel, 2002) and some of the cargo passing between Central America and CARICOM countries (Harding and Hoffmann, 2003). As of 2002, the port was directly linked to 13 other Caribbean ports (McCalla *et al.*, 2005).

Port-of-Spain, Trinidad intersects the north-south route, handling trade coming from the east coast of South America. The port also handles cargo passing between Central American countries and CARICOM countries (Harding and Hoffmann, 2003). Container traffic increased from 129,000 TEU in 1994 to 290,000 TEU in 2004 (McCalla *et al.*, 2005). Around 51% of the containers arriving at the port are transshipped (McCalla *et al.*, 2005).

Kingston, Jamaica. Located in the center of the GCR and close to the main shipping lines (McCalla *et al.*, 2005), the port of Kingston is the dominant hub port in the central Caribbean and is dependent on transshipments as a source of business (McCalla *et al.*, 2005). The port of Kingston (along with ports along the Atlantic side of Panama) handles a majority of transshipment cargo related to Central America (Harding and Hoffmann, 2003, UNCTAD, 2005). In 1997, the transshipment of containers at the port of Kingston accounted for approximately 80-90% of the container movements at the port (De Monie *et al.*, 1998). Container throughput at the port of Kingston increased from 339 thousand TEU in 1994 to 1.065 million TEU in 2002 (McCalla *et al.*, 2005).

Rio Haina, Dominican Republic. The Dominican Republic, located in the center of the GCR, is in the vicinity of the main shipping lines (McCalla *et al.*, 2005). The port of Rio Haina is less dependent on transshipments as a source of business than other countries in the GCR. The port handles transshipment cargo from Central America but tends to facilitate movements to smaller CARICOM countries (Harding and Hoffmann, 2003). In 2005, container traffic volume was reported at 268,000 TEU (Degerlund, 2007).

In addition, some emerging transshipment ports in the GCR are the Port of Caucedo, Dominican Republic, and the Port of the Americas, Ponce, Puerto Rico. Several other ports in the region handle a relatively small number of transshipments. If U.S. restrictions on Cuba are withdrawn, it is speculated that ports in Cuba will emerge as important transshipment ports (McCalla *et al.*, 2005).

Table 4.4 shows the number of vessels arriving in Caribbean countries. Unfortunately, we were not able to obtain data for all countries, nor was it possible to determine how many of the ships were carrying transshipment cargo or what the types and sizes of the ships were.

Involvement of Small Vessels in Intra-Caribbean Trade

Intra-Caribbean trade is the movement of cargo between countries of the GCR. The shipped commodities may either have been produced within the GCR, or may be products of other countries transshipped from the first port of entry in the Caribbean to another Caribbean port. Regardless of size, the majority of small vessels are involved in carrying fruits, vegetables and individuals' packages (**Table 4.3**).

"Inter-island transport is the province of an informal maritime transport sector, which is subject to few regulations which are variably enforced by port authorities" (Boerne, 1999). In a survey, 77% of the vessel operators interviewed were using shipping agents to handle customs processes and payments (Boerne, 1999). However, trade of fruits and vegetables often occurs without a shipping agent. Instead, farmers sell their produce directly to an individual who then transports the produce by small vessel to neighboring islands and sells it at the local market (Boerne, 1999). While small vessels tend to operate in a particular trade, they are rarely limited to one particular product. The length of the voyage is dictated by the type of trade rather than by the size of the vessel (Boerne, 1999).

Small ships (less than 150 gross tonnage (GRT)), "on average [have a] maximum cargo capacity of approximately 34.29 tons" and "the average cargo weight…of small vessels varies from 4.8 tons to 100 tons" (Boerne, 1999). For vessels under 150 GRT, between one and five TEUs can be carried, depending on vessel size (Boerne, 1999). The exact number of small ships operating in the Caribbean is not known; in fact, it is even difficult to estimate. Boerne (1999) estimated the number of small ships (less than 150 GRT) operating throughout the insular Caribbean to be around 200. The United Nations estimated around 400 to 500 small vessels operated throughout the Caribbean region; however, this estimate included vessels larger than 150 GRT (Boerne, 1999). Insufficient records and the spatial arrangement of maritime authorities in insular countries contribute to the shortage of data on inter-island vessel movement.

Characterization of Small Vessel Activity in Select Countries

Trinidad has a major transshipment operation, accepting cargo from throughout the world, which is then transferred to smaller vessels for distribution to other Caribbean countries. In fact, Port-of-Spain, Trinidad, is one of the most important small vessel ports in the region (Boerne, 1999). Shipments are mostly comprised of manufactured goods, including products manufactured in Trinidad. Vessel movement (at least in 1999) is primarily to Grenada and St. Vincent, but vessels have been reported to travel as far north as St. Maarten (Boerne, 1999). Upon return, small vessels bear agricultural commodities, such as fresh fruit and vegetables, spices, and even shipments of timber from Guyana (Boerne, 1999). Small vessels arrive at Port-of-Spain from St. Vincent, St. Lucia, Guyana, Barbados, and especially Grenada (Bertone and Gutierrez, 2008). Tobago receives small cargo vessels twice a day from Trinidad and no quarantine checks exist between Trinidad and Tobago (Bertone and Gutierrez, 2008). In 1999, exports to Jamaica ranked the highest at 1.4 million tons of cargo (not necessarily limited to small vessels) (CEPAL/ECLAC, 2001). The packaging of shipments arriving with small vessels varies greatly from loose boxes to palletized cargo (Bertone and Gutierrez, 2008). Reshipment of pallets from Jamaica and Bahamas requires fumigation prior to entry into Trinidad (Bertone and Gutierrez, 2008). Illegal trade with Venezuela is considered to be a pathway for the introduction of invasive species and a difficult pathway to control given the close proximity of the country to Trinidad (Bertone and Gutierrez, 2008). It is speculated that the fungus *Mycosphaerella fijiensis* (Ascomycetes: Mycosphaerellales), which causes black Sigatoka disease on banana, was introduced to Trinidad from Venezuela through illegal trade via small vessels (Bertone and Gutierrez, 2008). In the past, restrictions have been placed on cargo imported from Caribbean islands into Trinidad via small vessels due to quarantine pests (Boerne, 1999).

St. Maarten re-exports manufactured goods, such as electrical items from the United States and Europe, with islands to the south via small vessels. St. Maarten has a large tourist industry, and given its lack of natural resources, such as water, it is necessary to import fruits and vegetables, among other things, to sustain human activity. It is estimated that 48% of the small vessels operating between the Caribbean islands stop at St. Maarten (Boerne, 1999). The Port of Phillipsburg, St. Maarten (Netherlands Antilles) handles approximately 1,600 tons of cargo per month from (on average) 40 small vessels making call. Cargo includes primarily perishable products, such as fruits and vegetables. Small vessels commonly arrive from St. Vincent and the islands under United Kingdom authority (in the immediate vicinity this includes Anguilla, Montserrat, and U.K. Virgin Islands; further away is Turks and Caicos) (Boerne, 1999).

Saint Martin (French). The Port of Galisbay at Marigot is the main shipping port. On average, 60 small vessels make call per month and transport approximately 750 tons of cargo. Most of the small vessels arrive from islands under United Kingdom authority. Cargo includes perishable food products, electronic equipment, and manufactured goods (Boerne, 1999).

St. Kitts. The Port of Basseterre at St. Christopher receives about 225 tons of cargo per month from (on average) 28 small vessels. Imports include fruit from Dominica, general cargo from Puerto Rico, and electronics and other general cargo from St. Maarten. The island exports around 475 tons per month via small vessels, mostly concrete blocks and dairy products to Anguilla and Statia, and gas to Antigua.

Dominica. The Ports of Roseau and Portsmouth combined receive 60 small vessel calls per month. The amount of cargo handled by these vessels is not recorded, but estimates suggest that 1,110 tons are exported and 150 tons imported per month. Imports are mainly manufactured goods and electrical items (Boerne, 1999).

St. Lucia. The Ports of Castries and Vieux Fort are used by small vessels. In 1997, 750 tons of cargo, mainly fruits and vegetables, were shipped per month (it wasn't clear if this was the value of imports only or included exports) via (on average) 23 small vessels (Boerne, 1999).

Barbados. Small vessels call at the Port in Bridgetown. It is estimated that approximately 20 small vessels call, carrying approximately 700 tons per month of both imports and exports (Boerne, 1999). Details on the imports and exports were not provided.

St. Vincent and the Grenadines. The Port of Kingstown receives approximately 1,000 tons of cargo and exports approximately 150 tons of cargo per month. On average, 20 small vessels call per month. Small vessel transport is essential to this country, since it is comprised of nine islands. Fruits and vegetables are the principal exports. Imports are primarily comprised of manufactured goods, building materials, and processed food products (Boerne, 1999).

Grenada. The Port of St. George's and the Port in Carricou received approximately 1,200 tons of cargo per month in 1997, transported by small vessels. Around 51 small vessels call at Grenada per month, servicing ports that are unable to handle large vessels. Small vessels were responsible for carrying 4% of the total imports into Grenada; likewise, they were responsible for carrying 3% of the total exports. Imports were comprised of manufactured goods, building materials, and processed food products. Exports were comprised of fruits and vegetables, spices, and seafood (Boerne, 1999).

Guatemala. At the Port of Quetzal (Pacific side), small boats and private vessels are not inspected. They are only checked by port authority and immigration (Customs). Small boats can dispose of garbage at the port only if they provide sufficient advance notice; otherwise, they are not permitted to unload garbage (Meissner and Schwartzburg, 2008).

Summary

Maritime traffic is increasing in the GCR and is expected to continue to increase. The United States is a primary trading partner in the region; however, trade with other countries, including those in Asia and Europe, has expanded. At several ports, the establishment of transshipment services accounts for much of the increase in sea container traffic.

Tracking of intra-Caribbean trade is difficult and the level of regulation and record keeping varies greatly from country to country. It is possible that the movement of commodities between island countries through smaller vessels may be a means of moving pests between these countries.

Agricultural and non-agricultural shipments, cargo containers, and vessels themselves have been reported to be pathways for the movement of pests, pathogens, and weeds. Soil contaminants may also harbor unwanted organisms. The exact correlation between the increase in maritime and container traffic into and within the GCR and the introduction rate of pests, pathogens, weeds, and soil contaminants is not known.

Recommendations

- **Focus safeguarding efforts on the major transshipment ports for cargo from outside of the GCR.** The major transshipment ports (Colon, Panama; Kingston, Jamaica; Port-of-Spain, Trinidad) are where most of the cargo arrives from all over the world to be distributed within the GCR by small vessels. Focusing safeguarding efforts on these locations would require dealing with fewer entities (ports, ships, *etc.*) and may thus be easier and more efficient.

- **Monitor inter-island trade via small vessels.** Little data is available on inter-island trade, including the transshipment of cargo from one country to another via small vessels. Determine what commodities are being shipped, as well as their quantity, country of origin, country of destination, and the incidence of wood packaging material.

- **Implement risk communication strategies to educate local residents and business owners on the pest risks associated with trade.** Suggest specific strategies they can employ to reduce the risk of pest introduction.

Chapter 5: Hitchhiker Pests

Introduction

In the context of this document, we define a hitchhiker pest as an agricultural plant pest (insect, pathogen, mollusk, plant, *etc.*) which is moved to a different location not in association with a host commodity, but either in a commodity that is not a host, or on/in the conveyance (airplane, maritime vessel, *etc.*) or shipping container used for transport. This definition is different from the one provided in the glossary of phytosanitary terms of the International Plant Protection Convention (IPPC, 2007), which considers "hitchhiker" synonymous with "contaminating pest" but includes in this definition only pests carried by commodities, without providing a term for pests being carried directly on a conveyance or container.

Hitchhiker pests may arrive in or on a non-host commodity, conveyance, or container either by pure chance (*e.g.*, weed seeds that fall off of shoes) or, more commonly, because they are attracted by certain physical or chemical conditions. For example, flying insects may be attracted by lights during nighttime loading (Caton, 2003b, Fowler *et al.*, 2008); insects or mollusks may find shelter on or in cargo containers; *etc.* Pests that were originally associated with a host commodity may be left behind in a container or conveyance after unloading, thus becoming hitchhiker pests.

The scientific literature mentions numerous cases of hitchhiker pests that have arrived in new areas in cargo holds, aircraft cabins, maritime vessels, or shipping containers. For example, four species of Noctuidae and several species of Coleoptera and Homoptera are thought to have arrived in Guam in aircraft holds or cabins (Schreiner, 1991); the Oriental fruit fly, *Bactrocera dorsalis* (Diptera: Tephritidae), is believed to have been brought to Hawaii in military aircraft (Swain, 1952); the psyllid *Heteropsylla cubana* (Hemiptera: Psyllidae) was carried to Hawaii in the holds of cargo planes (Schreiner, 1991); and the red imported fire ant, *Solenopsis invicta* (Hymenoptera: Formicidae), was introduced into the United States in ship ballast (USDA, 2008a).

Sea cargo containers are suspected as the pathway of introduction for the painted apple moth, *Teia anartoides* (Lepidoptera: Lymantriidae), the southern saltmarsh mosquito, *Ochlerotatus camptorhynchus* (Diptera: Culicidae), and the varroa bee mite, *Varroa jacobsoni* (Acari: Varroidae), into New Zealand (MAF, 2003). The giant African snail, *Achatina fulica* (Pulmonata: Achatinidae), and Asian gypsy moth, *Lymantria dispar* (Lepidoptera: Lymantriidae), as well as snakes, have also been found associated with sea containers entering New Zealand ports (MAF, 2003).

The objective of this chapter is to discuss the likelihood of exotic hitchhiker pest movement into and within the GCR. Specifically, it addresses the following questions a) How common is the presence of hitchhiker pests? b) How likely are hitchhiker pests to survive transport? and c) How likely are hitchhiker pests to escape detection?

Discussion

Prevalence of Hitchhiker Pests

Aircraft. A number of scientific publications report interceptions of live pests in aircraft cabins and cargo holds. Goh *et al.* (1985) found that of 330 aircraft cabins examined at Changi International Airport, Singapore, 56 (17%) harbored insects. In a five-year study at the Manila International Airport in the Philippines, Basie *et al.* (1970) inspected over 14,000 airplanes, detecting 700 insects, the majority of which were dead mosquitoes. Evans *et al.* (1963) inspected the cabins and baggage compartments of over 1,800 aircraft entering Miami, Florida and found 1,700 arthropod specimens belonging to 68 families and 12 orders. The average number of arthropods per aircraft was 0.02 for baggage compartments, and 0.81 for cabins. A large proportion of the arthropods collected were species attracted to light. Rainwater (1963) found live agricultural pests on 0.6% of aircraft arriving in Hawaii from foreign countries. **Table 5.1** lists reportable pests intercepted in aircraft cargo holds at U.S. ports of entry between January 1, 1997 and December 31, 2007.

In a 1998-99 controlled study conducted at the Miami International Airport (MIA), inspections of the cockpit, galleys, exterior of palletized cargo, and cargo holds of 730 randomly selected cargo aircraft from foreign origins resulted in the detection of 151 live hitchhiking insects from 33 families in five orders, along with one plant pathogen (*Xanthomonas axonopodis* pv. *citri*) (Dobbs and Brodel, 2004). The study provides approach rates by country of origin, as well as estimates of about 10% of all foreign cargo aircraft and 23% of cargo aircraft from Central American countries arriving at MIA with live hitchhiking pests of quarantine significance.

In another study, Caton (2003b) reported an average of two flights daily arriving at MIA from Central and South America with quarantine pests in their cargo holds, estimating that one pest species per year may become established in Florida as a result of this pathway.

While the studies listed above provide some general indication of the pest risk associated with airplanes, they do not give us precise approach rates to estimate the number of annual pest introductions for the GCR overall or for specific locations within the region (with the exception of MIA). Approach rates are almost certainly different for cargo planes versus passenger planes. Approach rates should vary between countries of origin; as the proportion of countries of origin differs between destination airports, it follows that approach rates should be different for different destinations as well.

Another factor determining the number of airplane-related hitchhiker introductions is the number of airplanes arriving. Unfortunately, this information is very difficult to obtain. **Table 5.2** lists the number of arrivals for those Caribbean nations for which data was available; it does not distinguish between passenger and cargo planes.

Maritime vessels. Like airplanes, maritime vessels—both cargo and cruise ships—can harbor hitchhiker pests. Ship decks, holds, and stores have been found contaminated with live pest organisms, including species of Miridae, Cerambycidae, Curculionidae, Flatidae, and Scarabaeidae (**Table 5.3**) (USDA, 2008d). In 2007, some 15,000 ship inspections conducted at marine ports in the U.S. states of Florida, Alabama, Mississippi, Louisiana, and Texas resulted in over 4,000 plant quarantine material interceptions from ship stores and quarters (USDA, 2008f). Our team of analysts was able to observe insects and soil contaminations on a small vessel from Haiti moving up the Miami River (Lemay *et al.*, 2008). Experts also reported that "ship decks are sometimes covered with pests." PPQ no longer fumigates ship decks, and this pathway is thought by some experts to present a significant risk (Lemay *et al.*, 2008). Due to the immense size of maritime vessels and the time constraints under which phytosanitary inspections take place, it is very unlikely that hitchhiker pests on vessels will be detected. Therefore, we cannot quantify the frequency of hitchhiker pests occurring on ships, nor do we know whether certain vessel types are more prone to pest contamination than others.

Data is equally scarce regarding statistics of maritime vessel movement. **Table 5.4** lists available information on the number of vessel arrivals by country. Panama and the United States reported by far the most vessel calls. Port statistics often do not separate vessel types (*i.e.*, container vessels, break bulk cargo vessels, petroleum-carrying vessels) all reported in the same category. Container vessels often make numerous port calls, loading and unloading containers. It is not known if multiple port calls increase the risk of pest contamination for vessels or if vessels that make numerous port calls are more likely to play a role in the distribution of pests between countries.

Shipping containers. Like conveyances, shipping containers may harbor hitchhikers. Shipping containers vary in size and shape and may be composed of plastic, metal, or a composite of materials. The type of shipping container used depends on the mode of transportation. Standard twenty- and forty-foot containers (**Image 5.1**) are used in maritime shipping. Air cargo containers can be specialized to fit a particular type of aircraft and are typically smaller and lighter in weight (**Image 5.2**); however, some aircraft can accommodate standard twenty- or forty-foot containers. Pests, including arthropods, mollusks, and weeds, have been found on the outside and inside of shipping containers (Gadgil *et al.*, 2000, Stanaway *et al.*, 2001, Gadgil *et al.*, 2002, MAF, 2003). Soil, which can harbor fungi, nematodes, seeds, *etc.*, has also been detected on containers (Gadgil *et al.*, 2000). The risk of containers being internally or externally contaminated varies with the country of origin, time of shipping, storage and handling of containers, and other factors (MAF, 2003).

Image 5.1 Twenty- and forty-foot commercial shipping containers (image source: Gallmeister Internationale Spedition, http://www.ingo-gallmeister.de).

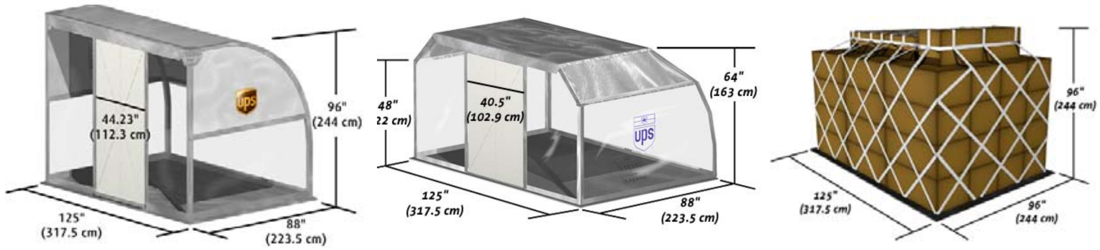

Image 5.2 Examples of air cargo containers. Air shipping containers differ in size and shape (left and center) and may not be completely enclosed (right) (image source: United Postal Service, http://www.ups.com).

In a four-sided (excluding the tops and bottoms), external survey of sea cargo containers arriving in New Zealand, soil was the main external contaminant and was found on an estimated 3.6% of loaded and 1.3% of empty containers (MAF, 2003).

Gadgil *et al.* (2000) inspected the exterior of 3,681 shipping containers arriving at New Zealand maritime ports and found soil on 31% of the containers, mostly on the underside of the containers. Of the containers contaminated with soil, 63% carried a low amount (10-50 g), 29% a medium amount (50-500 g), and 8% a large amount (>500 g) of soil. Fungi of taxa containing plant pathogens were isolated from 83% of the soil samples; species of *Fusarium* were commonly isolated. Nematodes were isolated from 81% of the soil samples. Foliage and woody material were the next most common contaminant. Egg masses of the Asian gypsy moth, *Lymantria dispar* (Lepidoptera: Lymantriidae), were found on two of the shipping containers. In another study, species of *Pseudomonas* were isolated from soil collected from sea cargo containers entering New Zealand (Godfrey and Marshall, 2002). Gadgil *et al.* (2000) estimated that containers from South Africa had the highest rate of contamination (50%), followed by the Pacific Islands (47.5%). Containers from the Far East, Japan, and East Asia had a contamination rate of 13%.

Internal contamination of soil, seeds, live insects/spiders, and/or plant material was found in approximately 21% of loaded and 18% of empty sea cargo containers arriving in New Zealand. Viable insects were present in 14.8% of loaded and 6.5% of empty containers (MAF, 2003).

In a different study involving sea cargo containers arriving at Australian ports, Stanaway et al. (2001) surveyed wooden components of the containers for pests, in particular timber-infesting insects. A total of 7,861 arthropods (1,339 of which were alive and were found in 6% of the containers) were found during the inspection of 3,001 containers. Although no live exotic timber-feeding insects were found in the wooden floors, insects with the potential to infest timber were found in just over 3% of the containers, suggesting that timber dunnage was the source of the infestation. In addition, 11% of the containers were contaminated with insects considered to be stored-product pests. The authors concluded that the risk associated with untreated wooden components of containers is not negligible because of the high volume of container traffic and the frequency with which containers come in contact with timber pests.

Air cargo containers arriving at airports in New Zealand were inspected by Gadgil *et al.* (2002), who found that the exterior, including the bottom, of the containers was generally clean (only 0.8% of the containers had external contamination), whereas on the inside, they found contaminants, mostly fresh leaves and twigs (24% of the cases). Fungi were found in soil contaminations on 3% of the examined containers. The detection of fresh plant material containing pests, coupled with the fact that newly introduced pests have been found in close vicinity to airports, led the authors to conclude that air cargo containers may provide a pathway by which exotic organisms can become established.

In the United States, pests of agricultural significance, including insects, mollusks, and weeds, have been intercepted on or in cargo containers (**Table 5.3**), regardless of the containers' contents. Taxa of agricultural significance intercepted on or in containers include crickets (Orthoptera: Gryllidae), which tend to be polyphagous, with some species being important agricultural pests (CABI, 2007). Several lepidopteran families have also been detected on containers, including Pyralidae, Gelechiidae, Limacodidae, and Pieridae. Several genera of Limacodidae are pests of coconut (*Cocos nucifera*), cocoa (*Theobroma cacao*), and banana (*Musa* sp.), which are commodities of economic importance in the GCR (CABI, 2007). The family Pieridae also contains many important crop pests. The cabbage caterpillar, *Pieris brassicae* (Lepidoptera: Pieridae), which was intercepted on a container, is not reported to be present in the GCR. This pest feeds on cruciferous crops and has been reported to cause significant damage during years of high population buildup. Migrations have been reported to occur (CABI, 2007). Also, intercepted on containers were chrysomelid beetles, which tend to be good fliers and often are agricultural pests. For example, the intercepted species *Aulacophora indica* (Coleoptera: Chrysomelidae) is not known to occur in the GCR and has caused melon crop failures in Indonesia (CABI, 2007). Beetles belonging to the families Scarabaeidae and Curculionidae (including Scolytid beetles), both of which contain devastating pest species, have also been found on containers.

Ants are of extreme concern. Tramp ant species, such as the red imported fire ant, *Solenopsis invicta,* or the Argentine ant, *Linepithema humile* (Hymenoptera: Formicidae), are ideally suited to spread as hitchhikers, being able to move their colonies easily and swiftly, to tolerate a wide range of environmental conditions, and to colonize new areas with amazing success.

Terrestrial mollusks are frequently intercepted hitchhikers at U.S. ports of entry (**Image 5.3**). They are typically polyphagous and many have been classified as general agricultural pests. In November of 2007, four species of mollusks were detected on a single shipment of ceramic ties from Spain at the port of San Juan, Puerto Rico (CBP, 2007). Examples of mollusks intercepted on containers that are not known to be established or are of limited distribution in the GCR are:

Image 5.3 Snails on containers at the port of Wilmington, North Carolina, USA. Source: (Robinson *et al.*, 2008).

- Species of *Candidula*, including *C. intersecta* (Hygromiidae)
- *Calcisuccinea* sp. (Succineidae)
- *Cathaica fasciola* (Bradybaenidae)
- Species of *Cernuella*, including *C. cisalpina* and *C. virgata* (Hygromiidae)
- Species of *Cochlicella*, including *C. acuta* (Cochlicellidae)
- Species of *Deroceras*, including *D. panormitanum* (Agriolimacidae)
- *Granodomus lima* (Pleurodontidae)
- Species of *Helicopsis* (Hygromiidae)
- Species of *Helix* (*H. lucorum* is a synonym of *H. aspersa*, which is reported in the U.S. states of Texas and Louisiana, and Haiti (CABI, 2007)
- *Microxeromagna armillata* (Hygromiidae)
- Species of *Monacha*, including *M. cartusiana* and *M. syriaca* (Hygromiidae)
- Species of *Otala*, including *O. punctata* (Helicidae) (suspected to be present in the U.S. state of Florida (Mienis, 1999))
- *Prietocella barbara* (Cochlicellidae)
- *Theba pisana* (Helicidae)
- Species of *Trochoidea*, including *T. pyramidata* (Hygromiidae)
- *Xerolenta obvia* (Hygromiidae)
- Species of *Xeropicta*, including *X. derbentina* (Hygromiidae)
- Species of *Xerosecta*, including *X. cespinum* (Hygromiidae)
- *Xerotricha apicina*, *X. conspurcata* (Hygromiidae)

In 2005, the GCR handled over 17 million twenty-foot equivalents (TEU)[11] of containers, loaded or empty, arriving or departing, at its maritime ports (**Table 5.5**). This is a rough estimate because not all locations reported TEU movement[12]. Unfortunately, not all ports report arriving and departing containers as separate categories, nor is it usually specified if the containers are being transshipped.

Image 5.4 Container yard in Costa Rica.

Transshipped containers enter a country through one port, are then loaded onto a different vessel, and exit for their final destination in a different country. The logistics of maritime trade in the Caribbean make transshipment a very common occurrence. Hitchhiker pest introduction may conceivably be facilitated by transshipment if containers are unloaded and stored at a port between vessel transports, as this would give

[11] TEU stands for twenty foot/feet equivalent units and is used to quantify containers, *i.e.*, 1 x 40 feet = 2 TEU; 1 x 20 feet = 1 TEU.

[12] Countries where container traffic data for 2005 was not available for one or more ports: Belize, Bonaire, Dominica, Grenada, Guyana, Haiti, Montserrat, St. Maartin, St. Vincent and the Grenadines, Suriname, and Turks and Caicos Islands. For those countries where data for 2005 was missing, data from the most recent year was used as an estimate. These countries are Anguilla, Antigua and Barbuda, British Virgin Islands, Guyana, Martinique, St. Kitts and Nevis, and U.S. Virgin Islands.

external hitchhikers an opportunity to leave the container and encounter favorable habitat.

Gadgil *et al.* (2000) estimated an approach rate of 23.4% (95% binomial confidence interval of 21.7 – 24.3%) for sea cargo containers arriving at New Zealand ports with external contamination of plant pests, pathogens, or soil containing plant pests or pathogens. In another study, 24.4% of loaded containers and 18.9% of empty containers entered New Zealand with contamination on the exterior or interior of the containers (MAF, 2003). Based on the approach rate estimated by Gadgil *et al.* (2000) and data on container movement, we calculated the expected number of contaminated sea cargo containers entering countries within the GCR (**Table 5.5**). Since most ports in the GCR report container traffic in the number of twenty-foot-equivalent units (TEUs) rather than number of containers, we had to convert TEUs to actual numbers of containers. We assumed an 80:20 ratio of number of forty-foot to number of twenty-foot containers, based on data provided by those ports which reported the number of arriving twenty- and forty-foot containers separately (Panama: Chiriqui Grande Terminal, Colon Container Terminal, Cristobal, and Manzanillo International Terminal; Guadeloupe; Nicaragua: Corinto; and St. Lucia: Port Castries and Port Vieux-Fort).

All other factors being equal, ports receiving a higher number of containers are at a higher risk of hitchhiker pest introduction. Overall, an annual 7 million containers are entering ports of the GCR, and we estimate 1.6 million of them to be contaminated with plant pests or pathogens (**Table 5.5**). Even though this is by no means an exact number, it nevertheless provides a general idea of the extent of the pest risk posed by maritime containers alone, regardless of their contents.

In summary, pest interception records at ports of entry in the United States, as well as controlled research studies, show that live hitchhiker pests are found on containers and conveyances. Several reports in the scientific literature have strongly implicated that pests, such as Asian gypsy moth, red imported fire ant, or land mollusks (Cowie and Robinson, 2003), have been introduced into new areas as hitchhiker pests.

Survival of Hitchhiker Pests During Transport

Pest survival in conveyances and containers depends on the combined effects of various environmental conditions (*e.g.*, temperature and relative humidity) and the duration of transport.

In modern commercial aircraft, cargo holds are pressurized and heated, generally maintaining a temperature of about 15°C (60°F) (Mikolajczak and Moore, 2001, Anonymous, 2007) with a normal temperature range of -1°C to 21°C (30°F to 70°F) (Anonymous, 2008a). Even when the temperature is not actively controlled, the hold temperatures after about 8 hours of flying at altitude are approximately 7°C (45°F) in some types of planes (Anonymous, 2007). Aircraft cargo holds may be cooled to accommodate perishable cargo, such as fruits, vegetables, and live plants, but these temperatures would not be lethal to most plant pests. Cargo holds of aircraft parked in freezing or hot weather will be subject to cold or heat conditions (Anonymous, 2008a).

A study by Russell (1987) reported very high survival rates of mosquitoes, *Culex quinquefasciatus* (Diptera: Culicidae), house flies, *Musca domestica* (Diptera: Muscidae), and flour beetles, *Tribolium confusum* (Coleoptera: Tenebrionidae) in unpressurized wheel bays of modern Boeing 747B at altitudes greater than 10,500 m. The study found that the temperature in the wheel bays ranged from 8°C to 25°C, even though the outside temperature was between -42°C and -54°C. Aircraft disinfection, while employed by some countries to reduce the spread of mosquitoes and other human disease vectors (CDC, 2007), is not uniformly performed. For example, the United States does not disinfect arriving aircraft (Kosciuk, 2007).

Pests located in outdoor areas of maritime vessels (*e.g.*, on ship decks), are exposed to the environmental and climatic conditions experienced at sea, including sea spray. However, pests may be protected by crevices and other sheltered areas. Certain life stages of the pest, such as insect pupae, plant seeds, encapsulated nematodes, *etc.*, tend to exhibit much higher tolerance of environmental conditions than active life stages. Transit duration is especially likely to play a role in pest survival for pests hitchhiking on the outside of unsheltered sea cargo containers or ship surfaces. The environmental conditions found in temperature-controlled cargo holds of maritime vessels or refrigerated containers that transport fresh fruits or vegetables or live plants would be above freezing to prevent damage to the commodity contained within. Transit times tend to be relatively short, ranging between a few hours for air transport to two weeks for longer-distance maritime transport. For example, maritime transit from the port of Limon in Costa Rica takes two-three days to Florida, five days to New Jersey or Canada and 12 days to Europe. Added to this must be the length of time the commodity is stored prior to shipment to the maritime port, transit time to the maritime port, and storage times at the port prior to vessel loading. In most cases, fresh agricultural commodities would be refrigerated during the entire duration of transit to ensure good quality of the product. However, most insects, plant pathogens, and mollusks would be able to survive this length of time at the prevailing storage temperatures of 3-7°C. In comparison, USDA-approved cold treatment schedules against fruit flies prescribe 2°C or lower for 14-22 days, depending on fruit fly species and commodity involved. Cold treatment against the pecan weevil, *Curculio caryae* (Coleoptera: Curculionidae), requires 0°C for seven days (USDA, 2008g).

The fact that numerous interceptions of live hitchhiker pests have been recorded at U.S. ports of entry demonstrates that many arthropods, mollusks, weed seeds, and plant pathogens are able to survive the prevailing transit conditions on or in aircraft, maritime vessels, and containers.

Detection of Hitchhiker Pests

According to data of the U.S. federal government (USDA, 2008d), 38,059 commercial cargo aircraft inspections were carried out at MIA during 2005-07, resulting in 677 interceptions of live plant pests of U.S. quarantine significance. This means that quarantine pests were found in at most 2% of the inspected airplanes. These inspections were routine port-of-entry inspections with no clear guidelines on inspection procedures. It is unclear what parts of the airplanes (underbellies, cabins, *etc.*) were inspected. In contrast, the controlled 1998-99 study by Dobbs and Brodel (2004) mentioned above resulted in an estimate of 10% of all foreign aircraft arriving in MIA with live plant pests of quarantine significance. Even though there is a nearly ten-year difference between these data sets, the discrepancy between these numbers may be a sign that phytosanitary inspections miss a large portion of the pests present.

There are several different reasons for this: First, the level of available staff and resources often is not sufficient for inspecting the immense number of incoming conveyances and containers, requiring ports of entry to focus on items considered as high-risk (Lemay *et al.*, 2008). Second, the amount of time available for inspection is often very short, as seen with some cruise ships that dock in the morning to depart again in the afternoon (Lemay *et al.*, 2008). Third, the large size and complex shape of airplanes and ships makes it very easy for pests to remain hidden and makes inspections very difficult. The task of inspecting a container vessel with a carrying capacity of over 8,000 containers is clearly very daunting. Furthermore, there are logistical challenges. For example, thorough inspection of the interior of a container entails removing all the cargo from the container and storing it during inspection. Given the perishable nature of some cargo, temperature-regulated storage facilities may be required. Access to the bottom of containers is restricted when equipment to lift the container is not available. It is not surprising that tailgate or door inspection comprises the majority of the inspections carried out at U.S. ports of entry (Lemay *et al.*, 2003, Meissner *et al.*, 2003, Lemay *et al.*, 2008). A study conducted at ports in New Zealand found that one-fifth of containers where tailgate inspection did not result in pest detection were found to be contaminated with pests upon more detailed inspection (MAF, 2003). The authors concluded that tailgate inspection only detected a small percentage of the containers arriving with live organisms (MAF, 2003). The same study also found that 15% of container contaminations occurred on the undersides of containers and will therefore not be detected with only a four-sided inspection (MAF, 2003).

Other factors impeding pest detection include:

- the size of the pest (minute pests are extremely likely to escape detection);
- quality and availability of inspection facilities and equipment;
- training level of the inspectors;
- competing work priorities for inspectors (*e.g.*, having to choose between focusing inspections on drugs versus pests); and
- human factors (*e.g.*, fatigue, lack of motivation, poor eyesight).

For procedural reasons, certain pest categories such as plant pathogenic bacteria and viruses, and nematodes are almost never identified and recorded at U.S. ports of entry.

Given the numerous impediments to intercepting hitchhiker pests, it is likely that a large portion of the pests arriving regularly on conveyances and containers at ports of entry in the GCR escape detection.

Recommendations

- ❖ **Encourage loading of vessels during times when the likelihood of pest entry is lowest.** For example, avoid nighttime loading because lights attract some major groups of quarantine-significant insects.

- ❖ **Clean containers and conveyances.** Evaluate effectiveness of currently used or available cleaning methods and make changes as appropriate.

- ❖ **Place traps on maritime vessels (commercial and cruise ships)** to catch insects and possibly mollusks present on vessels**.** Coordinate and share data throughout region. Ensure that traps do not attract pests onto the ship (*e.g.*, place lures/turn on trapping lights *etc.* only after ship is far enough from land). CISWG could be instrumental in coordinating the development of a trapping plan, possibly in coorperation with the U.S. Cooperative Agricultural Pest Survey (CAPS) Program and risk advisory groups such as BTAG and CRAG.

- ❖ **Monitor areas on and near the perimeter of the ports regularly** for introduced pests of particular interest (Robinson *et al.*, 2008). To reduce costs, employ the help of amateur taxonomists, university students, and qualified volunteers. Avoid attracting pests into the area (*e.g.*, through lures, lights, *etc.*).

- ❖ **Inspect empty containers, as well as containers with cargo.**

- ❖ **Minimize pest contamination on containers by:**
    - Minimizing time of container storage outdoors
    - Avoiding container storage on soil and near vegetation
    - Avoiding night-time lighting of outdoor storage areas
    - Cleaning storage areas on a regular basis
    - Cleaning inside and outside of containers after and before each use

- **Support studies to increase our understanding of the prevalence of hitchhikers on transshipped containers.** Focus on major maritime ports and airports that receive cargo from outside of the GCR. Evaluate likelihood of hitchhiker to be carried to final cargo destination given the current cargo handling procedures.

Chapter 6: Wood Packaging Material

Introduction

Wood packaging material (WPM) is used worldwide in shipments of both agricultural and non-agricultural products and includes dunnage, crating, pallets, packing blocks, drums, cases, and skids. WPM has been recognized as an important pathway for exotic species introductions (Pasek, 2000, Allen and Humble, 2002). Pests intercepted on WPM at U.S. ports of entry over the past 20 years include *Anoplophora chinensis* and *A. glabripennis* (Coleoptera: Cerambycidae), *Ips typographus* (Coleoptera: Curculionidae: Scolytinae), *Hylastes ater* (Coleoptera: Curculionidae: Scolytinae), *Monochamus* sp. (Coleoptera: Cerambycidae), *Trichoferus campestris* (Coleoptera: Cerambycidae) (USDA, 2008d), *Agrilus planipennis* (Coleoptera: Buprestidae) (McCullough *et al.*, 2007), and *Xyleborus glabratus* (Coleoptera: Cucurlionidae: Scolytinae) (Fraedrich *et al.*, 2007). In a recent study in China, various species of plant pathogenic nematodes of the genus *Bursaphelenchus* (Nematoda: Aphelenchoididae), including the pine wood nematode, *B. xylophilus*, were detected in WPM from 25 countries (Gu *et al.*, 2006).

WPM is believed to have been the pathway for several exotic pest introductions worldwide, including the pine wood nematode in Portugal, the wood boring beetles *Sinoxylon anale* and *S. senegalensis* (Coleoptera: Bostrichidae) in Brazil (Teixera *et al.*, 2002), the pine shoot beetle, *Tomicus piniperda* (Coleoptera: Curculionidae: Scolytinae) in eastern North America (Haack, 2001), and the Asian longhorned beetle, *Anoplophora glabripennis* (Coleoptera; Cerambycidae) in New York and Chicago (Bugwood, 1998). An African species of Bostrichidae, *Sinoxylon conigerum*, which was found to be present on teak and mango trees in Brazil in 2006, had been previously intercepted in Sweden in 2002 on wood pallets imported from Brazil (Filho *et al.*, 2006).

There are no regulations specifying the type of wood to use for WPM, and it is common to use low-grade or scrap wood to reduce cost (Pasek, 2000). Some bark and portions of the vascular cambium often remain on scrap lumber, providing a suitable habitat for bark beetles and their symbionts. Each piece of WPM may consist of one or more of any woody plant species and may be made from fresh-cut or seasoned lumber. Clark *et al.* (2001) list over 80 tree species as being used as raw material for pallets in the United States. Bush *et al.* (2002) report that hardwood species accounted for about two-thirds of the total wood used for pallets during the 1990s. Of these, about half were an unsorted mix of hardwood species, one-third were species of oak, and yellow poplar accounted for approximately 10%. Of the softwood used by the U.S. pallet industry, nearly half were southern pine; hemlock and Douglas fir accounted for about 10% each, and a mixture of spruce, pine, and fir for about a quarter of all softwood. Wood (*e.g.*, radiata pine and eucalyptus) for pallets may also be imported—often at a lower cost than domestic species—from countries such as New Zealand, Brazil, and Chile (Bush *et al.*, 2002).

WPM is frequently reused and reconditioned. Damaged or otherwise unusable pallets are disassembled for the wood parts, which are then used to either repair damaged pallets or to build reassembled pallets. In 1995, 18% of old pallets were recycled in this way (Clarke *et al.*, 2001). In 1995, recovered wood accounted for close to 27% of total wood use (both new and recovered). By 1999, recovered wood use had grown to 36% of total use (Bush *et al.*, 2002).

Because WPM is routinely reused and reconditioned (Bush *et al.*, 1997), the origin of the WPM is not necessarily the same as the origin of the commodity with which it is being imported (*e.g.*, WPM in a shipment from Canada may have originated in Australia). In one study, the pine wood nematode, *Bursaphelenchus xylophilus*, was detected not only in WPM from countries where it is known to occur, but also from countries considered free of this pest, and the global circulation of WPM was cited as the most likely explanation for this (Gu *et al.*, 2006).

In the United States, as in most other countries, it is not mandatory for importers to indicate the presence of WPM on the shipping manifest. This means that port quarantine officers have to rely almost exclusively on random checks and on their experience when selecting shipments for WPM inspection (Meissner *et al.*, 2003).

To reduce the pest risk associated with WPM worldwide, the International Plant Protection Organization (IPPC) developed the standard ISPM #15, "Guidelines for Regulating Wood Packaging Material in International Trade" (IPPC, 2006), which prescribes either fumigation or heat treatment for all WPM. WPM subjected to these approved measures is required to display a specified mark to facilitate the verification of compliance at ports of entry. The United States began enforcing ISPM #15 on September 16, 2005, with full enforcement for all types of WPM going into effect on July 5, 2006. From that date on, either fumigation or heat treatment became required for all WPM entering the United States from any country. Only a few countries of the GCR require treatment of WPM in accordance with ISPM #15 (Foreign Agricultural Service, 2008). These countries are: Colombia, Costa Rica, Cuba, Dominican Republic, Guyana, Guatemala, Honduras, Nicaragua, and the United States (Foreign Agricultural Service, 2008). In addition, Costa Rica requires a mark for heat treatment and another mark for methyl bromide fumigation. Guatemala's regulation is reciprocal, based on the exporting country's requirements (Foreign Agricultural Service, 2008).

While ISPM #15 undoubtedly reduces the pest risk posed by the movement of WPM, the degree of its effectiveness is not known. The ISPM #15-approved heat treatment requires a minimum core temperature of 56°C for 30 minutes. However, Qi *et al.* (2005) demonstrated that this treatment is not effective against the pine wood nematode, which was able to survive at a core temperature of 56°C for more than four hours and at a core temperature of 60°C for 3.5 hours. During the period of 1998 to 1999 alone, China recorded 44 and 28 cases of WPM contaminated with the pinewood nematode from the United States and Japan, respectively (Gu *et al.*, 2006). Between 2000 and 2005, batches of WPM imported into China from Japan, the United States, Korea, and the European Union showed infestations with various species of nematode averaging 21%, 21%, 17%, 24%, and 17%, respectively (Gu *et al.*, 2006). A study evaluating the effectiveness of ISPM #15 in Chile reported that several important quarantine species were intercepted on or in treated WPM, including *Sinoxylon anale*, *S. conigerum*, *Monochamus alternatus* (Coleoptera: Cerambycidae), *Pissodes castaneus* (Coleoptera: Curculionidae), *Tomicus piniperda*, *Heterobostrychus aequalis* (Coleoptera: Bostrichidae), and *Sirex noctilio*

(Hymenoptera: Siricidae), as well as *Ips* spp. (Coleoptera: Curculionidae: Scolytinae) and other *Pissodes* spp. (Sanchez Salinas, 2007).

In one study, bark- and wood-boring insects (mainly Curculiondiae: Scolytinae and Cerambycidae) were able to colonize and reproduce in logs that had been subjected to heat treatment (56°C for 30 minutes) and then placed in the field for one month or longer. The same was true for heat-treated wooden boards if they had any amount of bark on them (Haack *et al.*, 2006).

Ray and Deomano (2007) carried out a survey of U.S. and Canadian pallets and found that about 20% of them had bark on them, in spite of the fact that 88% of the pallets had been manufactured from de-barked raw material. The incidence of bark was approximately the same for all three bark-producing regions that were included in the study: U.S. West Coast, U.S. East Coast, and Ontario, Canada. It was also very similar for all pallet categories examined: stacked pallets, production pallets, hardwood pallets, softwood pallets, treated pallets, and non-treated pallets.

Surveys carried out at various U.S. ports of entry in the summer of 2006 revealed that approximately 10% of all WPM that arrived with an ISPM #15 mark (*i.e.*, had been treated according to ISPM #15) had some amount of bark on it, and about 0.1% harbored live wood-borers. The wood inspected in these surveys came from 50 different countries (Haack *et al.*, 2006).

The objective of this document is to discuss the potential role of WPM in commercial cargo in the introduction of exotic insect species into the Greater Caribbean Region (GCR).

Methods

Agricultural Quarantine Inspection Monitoring (AQIM) data on maritime and air cargo, which were collected by the U.S. Department of Homeland Security (DHS) Customs and Border Protection (CBP) between September 16, 2005 and August 15, 2007, were used to estimate the proportion of maritime and air cargo shipments that contain WPM. The data were collected at several ports throughout the United States based on the instructions in the USDA Agricultural Quarantine Inspection Monitoring (AQIM) Handbook (USDA-APHIS-PPQ, 2008b). Maritime shipments containing commercial cargo were selected randomly, and the presence or absence of WPM was recorded. The samples were divided into two categories: a) perishable, agricultural cargo, and b) non-agricultural (excluding Italian tiles). Regarding air shipments, samples were randomly collected from perishable, agricultural cargo, including cut flowers. Commodities specifically excluded from both air and maritime cargo sampling were:

- commodities which were pre-cleared at foreign sites;
- commodities admissible under the National Agricultural Release Program;
- frozen commodities;
- commodities which undergo some type of mandatory treatment other than cold treatment (*e.g.*, fumigation, irradiation, hot water treatment) at work locations; and
- oil, salt, iron ore, coal, and similar bulk materials.

The USDA PestID database was consulted for pest interception records at U.S. ports of entry for the corresponding dates.

Results and Discussion

Maritime cargo. In the case of perishable agricultural cargo, of 1,678 total shipments, 71% contained WPM, primarily (99%) pallets. Of the shipments with WPM, 16 (1%) arrived without the required ISPM #15 stamp. In the case of non-agricultural cargo, of 3,540 shipments, 77% contained WPM (57% were pallets, 25% crating, and 10% dunnage). Of the shipments with WPM, 298 (11%) arrived without the required ISPM #15 stamp. For both agricultural and non-agricultural shipments combined, 5,216 shipments were checked, and 75% of them contained WPM. In comparison, a similar study carried out in New Zealand between 2001 and 2002 revealed that about half of all maritime containers contained WPM (MAF, 2003). When 1998/1999 AQIM data were analyzed by USDA, about half of the cargo contained WPM.

Air cargo. Out of 2,837 air cargo shipments sampled, 33% contained WPM. Of these, 51 (5%) arrived without the stamp required by ISPM #15. Pallets were the most common type (at 97%) of WPM.

The percentage of cargo that contained WPM differed among countries of origin. (Only countries of origin with sample sizes of 30 or higher are discussed here.) In terms of maritime cargo (**Figure 6.1**), several Caribbean countries (Costa Rica, Guatemala, and the Dominican Republic) had high percentages of export cargo with WPM. Other countries with a high incidence of WPM in export cargo were New Zealand and several European countries. Cargo from Honduras, Nicaragua, Venezuela, and Panama had comparatively lower incidences of WPM. Shipments from China had the lowest incidence of WPM, significantly lower than that from most other countries. This was true for both agricultural and non-agricultural maritime cargo, confirming results reported by MAF (**Figures 6.2 and 6.3**).

In the air cargo samples, far fewer countries were represented. Notably, imports from the Netherlands had by far the highest incidence in WPM air cargo (**Figure 6.4**). In contrast to maritime cargo, air cargo shipments from Costa Rica and the Dominican Republic had a low incidence of WPM.

WPM does not only accompany commodity shipments but may also itself be the shipped commodity. World imports of WPM into the GCR during 2006 exceeded $6.7 million (**Table 6.1**). These values represent direct imports of both new and refurbished WPM. Within the Greater Antilles, all reported imports of WPM (from other countries within the GCR) were from the Dominican Republic or the United States into Jamaica. The Lesser Antilles received imports from Trinidad and Tobago, Jamaica, and the United States.

WPM exports from Caribbean countries (excluding the United States) during the year 2006 exceeded $11.2 million worldwide (**Table 6.2**). Products valuing $2.37 million were exported to other countries within the region, and SWPM valuing another $7.5 million were exported to the United States. Caribbean island exports were primarily from Jamaica and Trinidad and Tobago.

Obviously, the phytosanitary hazard is not presented by the WPM itself but by pest organisms that may be associated with it. Unfortunately, there is little published data available on the incidence of pests associated with WPM. The New Zealand Ministry of Agriculture and Forestry found that, of 1,517 maritime containers with WPM inspected, about 16% had contaminations that resulted in phytosanitary action, such as fumigation or incineration (MAF, 2003). Among the organisms detected on the WPM were a large number of fungi and insects, as well as isopods, millipedes, mites, plant materials, spiders, mollusks, and reptiles. A 2006 study carried out at several U.S. ports of entry resulted in an estimate of 0.1% of all marked WPM being infested with live wood-boring beetles (Haack *et al.*, 2006).

Table 6.3 lists organisms associated with wood intercepted at U.S. ports of entry between July 5, 2006 (date of full enforcement of ISPM #15) and January 1, 2008. The majority of the interceptions included wood-boring beetles of the families Cerambycidae and Curculionidae (including Scolytid beetles). A variety of other insect orders were also found, in addition to weeds and mollusks. These data suggest that live pests are entering with WPM in spite of ISPM #15. It is unknown whether the presence of pests is due to ineffectiveness of the required treatments, incorrectly applied treatments, re-infestation of the wood after effective treatment, or fraudulent use of the stamp/seal.

During the 18 months covered in **Table 6.3**, there were 427 interceptions involving 1,346 specimens. While this number may seem small in proportion to the volume of WPM entering the country, it nevertheless represents an average of over 20 interceptions comprising over 70 pest organisms every month.

It may safely be assumed that these port of entry interceptions represent only a fraction of the pests that are actually entering. One study estimated that inspections at the U.S.-Mexican border intercepted 30% or less of the incoming quarantine materials (Meissner *et al.*, 2003). Similarly, a report of the Hawaii Department of Agriculture stated: “Even during the Oahu risk assessment only about 10% of the [incoming cargo] volume was inspected, but the numbers of interceptions were about 10 times greater than the normal inspection of all of the HNL [Honolulu] cargo during that same period” (HDOA, 2007). These estimates refer to port inspections in general, not specifically to WPM inspections.

WPM is especially difficult to inspect, as pests are often hidden inside the wood and not all parts of a pallet or crate are visible to the inspector. Furthermore, a large part of the incoming WPM never gets inspected at all, especially if it is not associated with agricultural commodities. Since the implementation of ISPM #15, inspections of WPM are often limited to verification of the required seal, rather than a thorough inspection for pest organisms. Port inspectors are not always sufficiently trained for, or are not focusing on, the detection of wood-boring pests. A telling example involves training provided to USDA-APHIS Plant Protection and Quarantine (PPQ) port inspectors along the Mexican border in 2002. The training focused on methods for detecting scolytid beetles and resulted in an immediate and dramatic increase in pest interceptions in WPM. At Pharr, Texas, and San Diego, California, the average number of intercepted scolytid specimens increased from ≤ 1 to over 100 per month as a result of the training, suggesting that large numbers of scolytid pests had been entering the United States without being intercepted by

PPQ at these ports. The same probably holds true for most ports of entry worldwide and also applies to non-scolytid pests associated with WPM.

The New Zealand Ministry of Agriculture and Forestry underscored the importance of the particular inspection method used, reporting a 16% contamination rate when containers were inspected during devanning (*i.e.*, unloading of the cargo), compared to a 3% contamination rate found through tailgate inspections (*i.e.*, checking what is visible from the back of the truck without unloading the cargo) (MAF, 2003).

Table 6.4 lists species intercepted on wood at U.S. ports of entry, starting with the earliest available records from 1985. This list illustrates the large diversity of organisms that may be introduced over time through the WPM pathway. Some of the intercepted organisms, such as the Orthoptera, Hemiptera, and Diptera, are not taxa that are commonly known to be associated with wood. Rather, they traveled as true hitchhikers.

Each new establishment of one of these or similar pests anywhere in the world can increase the opportunities for further infestation of WPM and further spread. Many of these organisms may pose a significant threat to biodiversity, endemic plant and animal species, and, indeed, entire ecosystems. However, unless they are serious pests on important crops, their presence is likely to go undetected for a long time, especially in countries—such as many of the Caribbean countries—where resources for survey and detection activities may be limited.

Many pests intercepted on or in WPM have already been introduced into the GCR, but many still have the potential to spread further within that area. Species of the family Curculionidae, especially Scolytid beetles, are among the pests most frequently intercepted in association with WPM. In a 1994 survey of bark and ambrosia beetles in southern Florida, 20 of 83 scolytid species were considered introduced into that area (Atkinson and Peck, 1994). *Coccotrypes advena* (Coleoptera: Curculionidae: Scolytinae), recorded from Cuba and the Old World tropics, has been introduced into southern Florida and Suriname (Bright and Torres, 2006). *Premnobius cavipennis* (Coleoptera: Curculionidae: Scolytinae), occurring in a number of Caribbean islands, as well as Africa and Madagascar, has been introduced into both North and South America (Bright and Torres, 2006). *Xylosandrus morigerus* (Coleoptera: Curculionidae: Scolytinae) is only known from Puerto Rico in the GCR but is widespread throughout the world, is often intercepted at ports, and has been introduced into numerous countries (Bright and Torres, 2006).

The red imported fire ant, *Solenopsis invicta*, native to South America, has been intercepted on WPM and has been introduced into Puerto Rico and the Virgin Islands (Wetterer and Snelling, 2006). Impacts include reduction in biodiversity; injury or mortality of frogs, reptiles and small mammals; devastation of native invertebrate communities; and multiple social and economic problems for humans (Vinson, 1997, Allen *et al.*, 2004).

Mollusks are often found in association with WPM. The genus *Achatina*, which contains the giant African snail, *A. fulica*, has been intercepted at U.S. ports of entry on or in wood materials. *Achinata fulica,* a serious agricultural pest and a vector of various human pathogens, has been introduced into and is currently spreading within the GCR. *Pomacea canaliculata*, native to temperate and tropical South America, from Argentina to the Amazon basin, is another example of a WPM-intercepted mollusk that is now established in parts of the GCR (Florida and Dominican Republic). Negative impacts on native species include direct competition and the altering or disruption of suitable habitat (ISSG, 2008).

Table 6.5 lists some examples of insect species commonly associated with WPM that have the potential to become established in the GCR or to spread within the region if they are already established there.

The redbay ambrosia beetle, *Xyleborus glabratus* (Coleoptera: Curculionidae: Scolytinae), has recently been introduced into the southeastern United States. There, it is rapidly destroying endemic stands of redbay, *Persea borbonia*, by spreading the 'laurel wilt' disease, caused by the fungus *Raffaelea lauricola* (Fraedrich *et al.*, 2008). Other members of the Lauraceae are also hosts for the redbay ambrosia beetle, including sassafras, *Sassafras albidum*, and avocado, *Persea americana*. The potential consequences of an introduction of this beetle into the GCR are serious. Avocado, native to tropical regions of the Caribbean, Mexico, and South America, is an important agricultural commodity in the Dominican Republic, both for local markets as a staple food in the Dominican diet and for exportation. Other members of Lauraceae could be attacked as well, such as *Beilschmiedia pendula*, a tree endemic to the Antilles and a mast provider for birds and bats.

Not only animals are intercepted on WPM, but plants also could easily be introduced through the WPM pathway. For example, *Pennisetum polystachion*, a large grass native to Africa and India, has been intercepted on WPM in the United States. This grass competes with native plant species and can act as a host for maize streak virus. *Pennisetum polystachion* has spread to some Pacific Islands (ISSG, 2008), and other species within this genus have already invaded the Caribbean (Kairo *et al.*, 2003). *Ligustrum* species have been intercepted on WPM. Green privet, *L. lucidum*, is already an invasive tree in Bermuda, and this species, as well as others (*e.g.*, *L. sinense*, *L. robustum*) might easily spread through the Caribbean. All *Ligustrum* species have a tendency to be invasive, disrupting species composition and plant community structure (ISSG, 2008).

In summary, WPM is used all over the world and is routinely reused and reconditioned, so that often its origin cannot be determined. A large variety of wood-boring and other pests may be associated with WPM. The treatments prescribed by the International Standard ISPM #15 do not provide protection against all of these pests, and there are still many knowledge gaps regarding effectiveness. Also, wood that is pest-free after treatment may become re-infested over time.
In spite of ISPM #15, a large number of live pests continuously approach the United States on or in WPM. Port inspections detect only a small fraction of the pests approaching on or in WPM, leaving the larger part to enter the country. Several exotic species that have been intercepted on WPM have already established populations in the GCR, where they are feeding on economically or ecologically important hosts. A significant number of insects worldwide have the potential to be introduced into, and establish in, countries of the GCR.

Recommendations

- ❖ **Develop a strategy to ensure adequate inspection of WPM on all agricultural and non-agricultural cargo.** Simply checking for treatment seals is not a sufficient inspection method. A certain percentage of WPM should be randomly selected and thoroughly searched for pests, both on the surface and inside the wood. All pertinent information (type of cargo, origin of cargo, presence of treatment seal, types and number of pests found, *etc.*) should be recorded and shared region-wide.

- ❖ **Make the declaration of WPM mandatory for all imports.** The presence of WPM in a shipment should be declared on the importation papers. In addition, there may be a special mark (*e.g.*, a sticker) placed on containers that have WPM in them. This will help port staff more effectively target WPM for inspection.

- ❖ **Increase region-wide inspection and identification expertise on pests associated with WPM.** Educate inspectors on how to look for pests on WPM. Ensure that identifiers have the expertise and the necessary reference material to identify the pests that are found.

- ❖ **Carry out surveys to determine the distribution of pests commonly associated with WPM outside of their native range.** Collaborate with forest services, not-for-profit organizations (*e.g.*, CABI) and the Cooperative Agricultural Pest Survey (CAPS) Program. Involve the public. Use the help of hobby biologists. Do not exclude the countries that are enforcing ISPM #15 from these survey efforts.

- ❖ **Allow entry of WPM only if bark-free.**

- **Develop a communication network to share pest interception data, as well as inspection and diagnostic techniques, training materials, *etc.***

- **Encourage research to assess the effectiveness of ISPM #15.**

Chapter 7: Forestry-related Pathways

Introduction

Forests within the Greater Caribbean Region (GCR) fulfill a range of functions, including the production of both wood and non-wood commodities, direct and indirect contributions to local food security, and protection of soil and water, as well as providing habitats for wildlife and opportunities for recreation and tourism (FAO, 2005b).

All forests have immense economic and ecological value, but tropical forests are especially important on a global scale. Covering less than 6% of the earth's land area, these forests contain the vast majority of the world's plant and animal genetic resources. Forests of Puerto Rico, for example, contain more than 500 species of trees in 70 botanical families (Mastrantonio and Francis, 1997).

The GCR, encompasses over 230 million hectares of land, almost 40% of which is forested (**Table 7.1**), and contains an immense diversity of forest types. Caribbean island forests are tropical forests. Central American forests include tropical moist forests (rain forests), tropical hardwood, closed pine, mixed pine-hardwood, sub-montane and montane evergreen forests, and mangrove forests. Guyana and Suriname contain rain forests, seasonal forests, dry evergreen forests, marsh (including mangrove), and montane forests. Forest types in the U.S. Gulf States include pine, hardwood, mixed pine-hardwood, mangrove forests, and tropical hammocks (FAO, 2005c). This diversity of forest types offers establishment opportunities for a large variety of organisms.

Forests may act as a source of exotic species introduction when wood or non-wood forest products are exported. In the introduced range, these species not only may become forest pests, but may also impact agricultural production. By the same token, forests are at risk not only from pests introduced with forest products but also from pests introduced on agricultural commodities or through other pathways. For example, the pink hibiscus mealybug, *Maconellicoccus hirsutus* (Hemiptera: Pseudococcidae), is a destructive pest of both agriculture and forestry, infesting numerous tropical and subtropical fruit trees and forest trees. These include teak, *Tectona grandis* (Verbenaceae) and *Hibiscus eleatus* (Malvaceae), important plantation timber species throughout the Caribbean islands and Central America (FAO, 2000).

Propagative materials, such as plants or seeds imported for the purpose of planting, may not only serve as a pathway for the introduction of pests, but may also become pests themselves if they become invasive in the introduced range. For example, *Pittosporum undulatum* (Pittosporaceae), introduced into Jamaica in the late 1800s, takes advantage of vegetation gaps created by natural disasters (*e.g.*, hurricanes) to establish and outcompete native species. It is now considered one of the primary threats to the tropical forests of the Blue Mountains (Goodland and Healey, 1996, 1997).

Our objectives for this chapter are to discuss forests in the GCR as both sources and recipients of pest species and to outline various forestry-related pathways of pest movement. The pathways we discuss are: wood products, non-wood forest products, and trees for planting. The important topic of wood packaging material is covered in a separate chapter of this report and is therefore not addressed here.

Discussion

Pathway: Wood Products

Wood products include unmanufactured products such as logs, poles, pilings, pickets, stakes, untreated railway ties, and fuelwood, as well as finished goods, such as furniture, wooden handicrafts, musical instruments, broomsticks, and myriad other items.

Raw wood products in particular are vulnerable to pest infestation or contamination throughout the trading process, beginning with the timber extraction process (**Figure 7.1**). Trees are felled either manually with a chainsaw or utilizing heavy forest equipment. On-site processing includes delimbing, topping (removing the upper part of the tree), bucking (division of the tree into log lengths), and sometimes chipping (slicing trees or parts of trees into small pieces) (Rummer and Erwin, 2008). The primary extraction process moves the felled trees or logs from the stump to the landing most often through a process called skidding. Skidding (dragging logs or trees across the ground) can be accomplished in a variety of ways, including animals, tractors, cables, or helicopters (Rummer and Erwin, 2008). The skidded logs are left at the landing for loading onto secondary transportation. Timber may be sorted (separated by species or grade) at the landing, then transported further to the processing facility. Finally, the timber is moved to a port and loaded onto the shipping vessel.

Obviously, any pests infesting or attached to the standing trees (*e.g.*, bark beetles, wood borers, plant pathogens, snails) are likely to be moved to new locations with the wood, but additional contaminants may also be picked up by the wood after felling. For example, plant pathogens may get onto the wood from contaminated saws or chippers; logs may pick up soil, insects, pathogens, or weed seeds during the skidding process (Roth *et al.*, 1972); and pests that may not have been associated with the standing tree may infest the felled log at the landing, the central yard, the shipping yard, or even en-route.

Best management practices (BMPs) in forestry are voluntary measures implemented by loggers and foresters in an effort to control soil erosion and to protect water quality. Among the BMPs related to timber harvesting, one of the most critical is to minimize soil disturbance (AFC, 2007). Without good sanitary processes, there is the possibility of introducing contaminants into the logging site (**Image 7.1**). Forest equipment may be encrusted with soil containing plant pathogens, nematodes, or weed seeds (Roth *et al.*, 1972, Jules *et al.*, 2002, Waterhouse, 2003); snails or insects may be hitchhiking on vehicles; saws and chippers may be contaminated with pathogens from trees they have touched; workers may have contaminants on their shoes and clothing; animals used for transport may carry weed seeds on their fur or in their intestinal tract (Richardson *et al.*, 2004).

The disturbance caused by the logging process (*e.g.*, the creation of logging roads) may create conditions that facilitate the establishment of introduced pests (USDA-FS, 2001). For example, plant species with low shade tolerance may not be able to grow in a dense, undisturbed rain forest but can thrive in the vegetation gaps created by the logging.

Image 7.1 Illegal logging road in Panama (panamaguide.com).

Illegal logging is a widespread problem in the GCR, particularly in Central America (Galloway and Stoian, 2007, Wells *et al.*, 2007). This presents a special challenge for any efforts to implement sanitation practices or inspections.

Image 7.2 Cutting logs in Guyana for export (Source: guyanaforestry.blogspot.com)

Raw wood, particularly with the bark intact (**Image 7.2**), can serve as a potentially serious pathway for the movement of exotic forest pests. Bark beetles and ambrosia beetles (Coleoptera: Curculionidae: Scolytinae), wood-boring beetles (Coleoptera: Buprestidae), longhorned beetles (Coleoptera: Cerambycidae), and horntail wasps (Hymenoptera: Siricidae) are among the most destructive forest insects; each of these groups is associated with raw timber products (Ciesla, 1992). USDA pest risk assessments provide extensive lists of insects and pathogens associated with *Pinus* (Pinaceae) and *Abies* (Pinaceae) logs from Mexico (USDA-FS, 1998) and with *Pinus* logs from Australia (USDA-FS, 2006b). In a different pest risk assessment, 801 species of arthropod pests were found to be associated with wood from China (USDA-APHIS, 2007). Bark beetles and wood-boring beetles entered China in unprocessed *Pseudotsuga menziesii* (Pinaceae) and *Tsuga heterophylla* (Pinaceae) logs from the United States (Ciesla, 1992); and *Pinus radiata* logs exported from New Zealand were found to be infested with *Hylurgus ligniperda* (Coleoptera: Curculionidae: Scolytinae) (Speight and Wylie, 2001).

A recent introduction into the southeastern United States of *Raffaelea lauricola* (Ascomycetes: Ophiostomatales), a fungal symbiont of *Xyleborus glabratus* (Coleoptera: Curculionidae: Scolytinae) and the causal agent of laurel wilt in trees of the Lauraceae family, is causing increased mortality in *Persea borbonia* (Lauraceae) (Koch and Smith, 2008). The primary pathway for introduction of *X. glabratus* is believed to be wood products (raw wood and wood packaging material) (Rabaglia *et al.*, 2006). Efforts are underway to prevent the continued spread of *X. glabratus*, but infestations are increasing throughout the southeastern United States, and spread models predict a high likelihood of spread throughout certain parts of the United States, including all Gulf States. This pest is a potential risk for the Caribbean islands. Numerous trees and shrubs in the Lauraceae family, including avocado, *Persea americana*, appear to be susceptible to the pathogen (Fraedrich *et al.*, 2008).

Fuelwood includes logs, billets, twigs, chips or particles, sawdust, wood waste, and scrap wood. Logs used as fuelwood generally differ from those used for timber products by size and quality. However, many of the pests associated with fuelwood, particularly in the form of logs and twigs, are the same as those associated with raw timber. Wood chips, though of somewhat lower pest risk than unprocessed wood, may still harbor many pests, including *Phellinus weirii* (Agaricomycetes: Hymenochaetales); *Bursaphelenchus xylophilus* (Tylenchida: Aphelenchoididae); *Monochamus* spp., *Anoplophora glabripennis*, and *Tetropium fuscum* (Coleoptera: Cerambycidae); and *Gnathotrichus* and *Trypodendron* spp. (Coleoptera: Curculionidae: Scolytinae) (Magnusson *et al.*, 2001). Scrap wood (sawdust, wood chips, wood shavings, and wood wool) coming into New Zealand was found to harbor fungal pathogens (*e.g.*, *Cryphonectria cubensis* (Sordariomycetes: Diaporthales), bark and wood-boring beetles (Coleoptera: Cerambycidae, Cucurlionidae), and termites (Rhinotermitidae and Kalotermitidae) (NZMAF, 2003).

Tables 7.2-7.7 depict trade of raw wood reported by the Caribbean countries in 2006, illustrating the fact that there are substantial quantities, both coniferous and deciduous, moving into and within the GCR. The Caribbean islands, Central America, Guyana, and Suriname report imports of over 16,000 metric tons of raw wood from throughout the world (**Table 7.2**). Almost half of these imports consisted of coniferous species. Exports (including exports from the U.S. Gulf States into the GCR) exceed 293,600 metric tons (**Table 7.6**). The majority (77%) consisted of tropical hardwoods, much of it from Central America and Guyana exported into the United States. Over 70% of the raw wood exported from the Gulf States into the GCR originated in Florida and was destined for the Caribbean islands (UNComtrade, 2008). It is important to note that these data reflect only raw wood (untreated, with or without bark) reported by the importing and exporting countries; WPM, lumber (treated or untreated), and plywood are not included in these tables.

Raw wood is not the only wood of phytosanitary concern. Manufactured wood items, such as wooden handicrafts, musical instruments, brooms, tools, toys, wooden poles for artificial Christmas trees, and many other items may also be infested with pests. A U.S. pest risk assessment found 510 species of U.S. quarantine significance to be associated with manufactured wood from China (USDA-APHIS, 2007).

Pathway: Non-Wood Forest Products

Non-wood forest products (non-timber forest products) include food products (*e.g.*, nuts, berries, leaves, ferns, edible fungi, bark), gums, resins and latexes of plant origin, medicinals (*e.g.*, leaves, bark, roots, whole plants, fungi), bark and other plant material for dyes and tannins, rattan, palms, bamboo, craft products (*e.g.*, mosses, bark, willow reeds, vines), floral and decorative products, and landscape products (FAO, 2005b). Rattan-like items used for furniture, baskets, mats, *etc.*, could potentially harbor insect pests and plant pathogens (NZMAF, 2003). Mahogany bark is collected in Jamaica for making dye and mangrove bark is exported from Guyana for tanning leather. Bark is a known pathway for the movement of insect pests and pathogens (NZMAF, 2003). Depending upon the condition of the bark during transport and upon delivery, the material could easily provide a pathway for numerous bark-infesting insects and pathogens (**Appendix 1**).

Christmas trees, too, have been vehicles for the introduction of exotic pests into the GCR; imports of Christmas foliage (coniferous species) were found to contain *Adelges cooleyi* (Hemiptera: Adelgidae), *Chionaspis pinifoliae* (Hemiptera: Diaspididae), *Paradiplosis tumifex* (Diptera: Cecidomyiidae), and others (Speight and Wylie, 2001). After implementing the Canadian Christmas tree contingency action plan in Puerto Rico, which expedited inspections and improved pest identification and customer service, interceptions on this commodity of mollusks increased seven-fold and interceptions of insects doubled (USDA-APHIS-PPQ, 2008a). If paying special attention to a pathway significantly increases pest interception rates, then this means that without that special attention, many pests remain undetected and the risk associated with that pathway may be underestimated.

Plants and plant products have been utilized as medicines throughout history and play an important role in human activities, and international trade in these commodities is increasingly gaining momentum. Natural products are often the only source of medicine for 75-90% of the people living in developing countries (Wilkie *et al.*, 2002). A medicinal plant collection from the island of Montserrat consists of 278 taxa from 78 families (Brussell, 2004). A study into the medicinal plant trade in Suriname (vanAndel *et al.*, 2007) revealed that over 245 species of medicinal plants were sold in local markets and that the annual value of the domestic and export market was estimated to be worth over US$1.5 million. Plants were selling at local markets in various forms (*e.g.*, leaves, fruits, roots, bark, whole plants) (**Image 7.3**), and most plants were gathered from the interior forests and transported to market.

Image 7.3 Medicinal plants at a local market in Paramaribo, Suriname (Photo: Sara Groenendijik).

Little is known about medicinal plants as a pathway for the introduction of plant pests; however, given the growing importance of the medicinal plant market and the immense variety of medicinal herbs that may potentially be involved, this topic is worthy of attention.

Bamboo, *Bambusa vulgaris* (Graminae), was introduced into the Caribbean to control soil erosion along steep dirt roads (Francis, 1993); it has become established along streams and has formed monocultures in some riparian areas, and questions are being raised as to its invasive potential and risks to native forests (Blundell *et al.*, 2003). While not considered one of the more threatening species, *B. vulgaris* is considered to be invasive in Jamaica and Tobago (Kairo *et al.*, 2003). In the GCR, bamboo is used for fences, furniture, scaffolding, arbors, and various forms of farm construction. Bamboo is also a favorite species for handicrafts, kitchen items, garden accessories, screens, furniture, and musical instruments (Francis, 1993). A number of Caribbean countries have taken steps over the past few years to increase the production of bamboo products. For example, Jamaica and Guadeloupe signed a memorandum of understanding to promote bamboo products (JIS, 2006). INBAR, the International Network for Bamboo and

Rattan, headquartered in China, has signed an international agreement with a number of countries, including Cuba, Suriname, and Jamaica, to increase bamboo production and trade in the Caribbean, Central America, and South America (JIS, 2004, INBAR, 2006).

Dried bamboo, particularly *B. vulgaris*, has been found to serve as a pathway for phytophagous insect pests from China (**Image 7.4**). A review of U.S. port interceptions from China from 1985 through 2005 revealed that 26 species of live insects of phytosanitary concern were found in dried bamboo garden stakes from China, including eight genera of Coleoptera: Cerambycidae (*Anelaphus, Chlorophorus, Elaphidion, Niphona, Phymatodes, Purpuricenus, Sternidus,* and *Xylotrechus*). Twelve other families were represented (USDA-APHIS, 2006). Two high-risk beetle species from families represented multiple times in the interceptions were *Chlorophorus annularis* (Cerambycidae) and *Heterobostrychus aequalis* (Bostrichidae). These insects have high dispersal potential, a wide range of hosts, and can contribute to substantial economic losses.


Image 7.4 Larvae in bamboo stakes (Source: APHIS 2005).

In 2006, China reported exports of 1352 metric tons of bamboo[13] into the GCR (excluding the United States) (UNComtrade, 2008), with almost 80% going to Central America. The Caribbean islands, chiefly the Dominican Republic, Dominica, and Trinidad and Tobago received the remaining 20%, with the exception of a very small amount (< 1%) going to Suriname. There was also significant intra-Caribbean trade of bamboo products during the same time period.

Pathway: Trees for Planting

Numerous exotic plant pests have been introduced into North America on nursery stock and propagative material. These include pathogens such as *Cryphonectria parasitica* (Sordariomycetes: Diaporthales) and *Cronartium ribicola* (Uredinomycetes: Uredinales) (Ostry, 2001). An example from tropical forests is the introduction of *Pineus pini* (Hemiptera: Adelgidae) into Kenya and Zimbabwe on pine scions from Australia; *P. pini* spread to six additional countries in Africa, primarily through the movement of infested nursery stock (Odera, 1974). Pathways associated with nursery stock and propagative materials are addressed in Chapter 8.

Plantations are established in the GCR for timber production, to provide local sources of fuelwood, and to protect and restore the land (FAO, 2000). Agroforestry systems are employed throughout Central America and the Caribbean islands to effect these goals and to provide

[13] The trade data reported from UNComtrade include HS-96 tariff codes 14110 (bamboo used primarily for plaiting—includes bamboo poles), 460110 (bamboo used primarily for plaiting), 460120 (mats, matting, and screens), and 460210 (basketwork, wickerwork, and products of vegetable material – includes bamboo fencing). Bamboo can be included in any number of HS codes, including those related to wood and anything related to "vegetable material." Accurate accounting of bamboo trade is impossible under the present system.

companion plantings for food crops, pastures, or animals (Scherr, 1999). Agroforestry provides many advantages, but it is becoming more widely recognized that some of the trees used in commercial plantations and in agroforestry operations are invasive species themselves (Richardson, 1998). The most successful invaders in natural environments tend to be woody perennials, especially trees (Cronk and Fuller, 1995). The characteristics that contribute to a tree's invasive potential include rapid growth, high fecundity, small seeds, and the ability to fix nitrogen; these are the same characteristics that often make a tree species a desirable candidate for agroforestry operations (Richardson *et al.*, 2004).

Invasive plantation and agroforestry tree species in the GCR include *Acacia* spp., *Leucanea leucocephala* (Fabaceae), *Melaleuca quinquenervia* (Myrtaceae), *Schinus terebinthifolius* (Anacardiaceae), and others (**Table 7.8**). These species often form dense thickets or monocultures, replace native vegetation, disrupt activities of native fauna (*e.g.*, in Florida, turtles are prevented from nesting and often trapped in the roots of *Casuarina equisetifolia* (Casuarinaceae)), and lower the water table (Binggeli *et al.*, 1998). Some are capable of invading undisturbed forests (*e.g.*, *Adenanthera pavonina* (Fabaceae)) and causing further degradation of native forests by changing species composition and decreasing biodiversity (Green *et al.*, 2004). The alien tree *Acacia mearnsii* (Fabaceae), which is the center of a commercial wood-products industry in South Africa, has invaded almost 2.5 million ha of native ecosystems there, where it threatens water resources, biodiversity, and the stability of riparian habitats (deWit *et al.*, 2001).

Potential Consequences of Exotic Forest Pests

The overwhelming majority of Caribbean forests are tropical forests with extremely high levels of species richness (FAO, 2005b). The number of endemic tree species ranges from the hundreds to the thousands in some areas (FAO, 2005b), and many of them are listed as vulnerable, endangered, or critically endangered on the International Union for Conservation of Nature and Natural Resources 'red list' (IUCN, 2007). The pressures already impacting the forests of the GCR may exacerbate both the forests' susceptibility to exotic species invasions and the consequences such invasions may have.

Undisturbed old-growth forests are generally considered to be impervious to invasion by exotic species (Simberloff, 1981, Herbold and Moyle, 1986, Huston, 1994, Hooper *et al.*, 2005, Stachowicz and Byrnes, 2006), and the most important indicator for susceptibility of an ecosystem to invasion is believed to be whether or not it has been disturbed. However, it is becoming more evident that even undisturbed forests are vulnerable to exotic pests. For example, three exotic ambrosia beetles, *Xylosandrus crassiusculus*, *Xyleborinus exiguus*, and *Euwallacea fornicatus* (Coleoptera: Curculionidae: Scolytinae) have been found in old-growth forests in Costa Rica and Panama (Kirkendall and Ødegaard, 2007). *Xylosandrus crassiusculus* is an aggressive, high-risk quarantine pest in North America. Host genera for *X. crassiusculus* include *Tectona* (Lamiaceae), *Cecropia* (Cecropiaceae), *Lecythis* (Lecythidaceae), *Calliandra* (Fabaceae), *Quercus* (Fagaceae), and *Ulmus* (Ulmaceae). Host genera for *X. exiguous* include *Brosimum* (Moriaceae) and *Protium* (Burseraceae). *Euwallacea fornicatus* hosts include *Cedrela* (Meliaceae), *Tocoyena* (Rubiaceae), and *Brosimum* (Moraceae) species. The specific pathways for these insects into Central America are unknown, but bark and wood-boring insects are frequently intercepted on logs and wood packaging material and these are the likely pathways for introduction (Brockerhoff *et al.*, 2006, Haack, 2006).

In regard to weed trees invading interior forests, it was recently observed that over 139 exotic plant species have invaded deeply shaded forest understories that have not undergone any substantial disturbance (Martin *et al.*, 2008). The rate of invasion by shade-tolerant species is slower than that of shade-intolerant species, but the long-term impacts on forest ecosystems can be perhaps more detrimental. A recent study of long-term alien tree invasions in Puerto Rico revealed that exotic trees such as *Spathodea campanulata* (Bignoniaceae) and *Psidium guajava* (Myrtaceae) established on abandoned agricultural lands, forming monocultures, while the evergreen, shade tolerant *Syzygium jambos* (Myrtaceae) invaded shade coffee forests and native forests (Lugo, 2004).

Important timber species in Central America and the Caribbean islands include *Tectona grandis*, *Gmelina arborea* (Lamiaceae), *Cedrela odorata*, *Swietenia* spp., and *Pinus caribaea* (FAO, 2000). Latin American and Caribbean plantations cover almost 10 million hectares (Ball *et al.*, 1999), 56% of which are hardwood species. Plantation establishment is increasing, especially of *Tectona grandis* and *Gmelina arborea*. It is projected that by 2020, 60% of sustainable wood supply in Latin America and the Caribbean will come from plantation forests (FAO, 2006). Important plantation timber species in the Gulf States are *Pinus echinata, P. elliottii, P. palustris*, and *P. taeda*. All of these timber species are associated with a suite of forest pests, some native, some already introduced, and some that may be a threat to the GCR. These pests, along with those that may infest native forests, are listed in **Appendix 1**.

Pines (*Pinus* spp.) are vulnerable to many species of bark beetles and wood borers. Central American countries (*e.g.*, Honduras and Belize) have been experiencing severe outbreaks of the native *Dendroctonus frontalis* (Coleoptera: Curculionidae: Scolytinae) over the past few years (FAO, 2008). Honduras is one of the few tropical countries with large areas of natural conifer forests, including many endemic *Pinus* species (FAO, 2005a). Because of the preponderance of *Pinus* species, both in natural stands and plantations, the introduction of certain exotic pests, such as *Sirex noctilio* (Hymenoptera: Siricidae), into the Gulf States and Central America could result in severe damage. *Sirex noctilio*, native to Eurasia and northern Africa, has been introduced into Australia, South Africa, and parts of South America, resulting in one of the most damaging biological invasions of pine forestry in the southern hemisphere (Hurley *et al.*, 2007). Climate-matching models predict that *S. noctilio* could establish and persist throughout North and Central America wherever susceptible hosts are located (Carnegie *et al.*, 2006).

Summary

Forests provide multiple ecological, economic, and social functions throughout the GCR. Most of the forests within the region are classified as tropical and are important on a global scale for their immense ecological value. Forests throughout the region are being degraded, largely through the effects of increasing human populations and non-sustainable logging practices, making them more vulnerable to the effects of exotic species.

Important forest pests include insects, pathogens, and plants, especially invasive tree species. Important pathways for the introduction of exotic forest pests, pathogens, and weeds include both wood and non-wood forest products, as well as propagative materials, such as trees for plantations or agroforestry systems. Hitchhiker pests can be moved through the timber extraction process. It is important to note that exotic forest pests moving through each of these pathways may impact both natural systems and agricultural systems.

Due to a lack of data, it is difficult to determine the relative importance of each of these pathways. Furthermore, we know very little about introduced species (how many and which species) that may have already established in the GCR, especially in forested areas. More research in this area is needed.

Recommendations

- **Hold an international congress on introduced and imminent forest pests in the GCR.** The conference may be coordinated by Carribean Invasive Species Working Group (CISWG) and may be modeled after a similar conference held by FAO in 2003 (FAO-RAP, 2005). The main objectives of the conference should be to:
  - increase awareness of the threats of invasive species to forests and forest products;
  - share information related to exotic forest pests; and
  - develop action items for regional cooperation in addressing forest pests.

- **Establish criteria for assessing invasive potential for exotic tree species that are under consideration for agroforestry.** The USDA-APHIS-PPQ-Center for Plant Health Science and Technology may be able to provide expertise in weed risk assessment.

- **Exclude tree species with high invasive potential from agroforestry systems.** Fast-growing and readily reproducing tree species are often preferred for plantation planting. However, these species also have a greater potential to become invasive. As much as possible, promote the use of local tree species in agroforestry and reforestation.

- **Carry out surveys to determine the distribution of pests commonly associated with wood and non-wood forest products outside of their native range.** The efforts of Kairo *et al.* (2003) would provide a useful foundation for this.

- **Establish Best Management Practices to reduce the potential movement of forest pests.** These could include:
  - Sanitation procedures such as cleaning forest equipment after each use
  - Prevent contamination of logs with soil or weeds
  - Prevent hitchhiker pests
  - Prevent new infestations of cut logs (protect stored logs)
  - Limit the movement of untreated firewood

Chapter 8: Plant Propagative Material

Plant propagative material, also referred to as nursery stock, is any plant material capable of and intended for propagation, including buds, bulbs, corms, cuttings, layers, rhizomes, root clumps, scions, stolons, seeds, tubers, or whole plants. In this chapter, the term "propagative material" includes plants for planting.

As a pathway, propagative material overlaps with the other pathways discussed in this report in that propagative material may be transported by any of the available methods: airplane, cargo vessel, small boat, truck, personal vehicles, public or private mail, as well as in the baggage of ship, plane or bus passengers.

Propagative material is mainly imported for commercial nursery and horticulture production and uses in agriculture and forestry. Smaller quantities are imported for "plant exploration" by botanical gardens or researchers, or planting (*e.g.*, as ornamentals or food plants) by private collectors or homeowners.

In the Greater Caribbean Region (GCR), the demand for propagative material is strongly linked to tourism development, and there can be great economic and political pressure to allow needed imports. Spikes in demand also tend to occur during renovation and reforestation efforts after hurricanes and other extreme weather events (Klassen *et al.*, 2004).

The trade of propagative material is a multi-billion dollar industry. The United States, together with Canada, Israel, and the Netherlands, are the major exporters of nursery products to the GCR (UNComtrade, 2008). Available data on the commercial trade of propagative material are categorized by harmonized tariff codes and do not contain the taxonomic identity of the imported commodities. Compounding the difficulties in data colelction, not all countries report their trade data (UNComtrade, 2008) (**Tables 8.1-8.6**), and there is no way of quantifying the unofficial, unregistered trade that occurs among Caribbean nations.

Based on official trade data, the propagative materials most frequently traded fall into the category of "bulbs, tubers, tuberous roots, corms, crowns and rhizomes." Almost 17 million plant units of these types were imported into countries of the GCR in 2007, nearly all of them from the Netherlands into Colombia. Slightly fewer than 1 million were imported from Canada into Guatemala (**Table 8.1**). The next most frequently traded articles fall into the category "live plants (not otherwise specified) including their roots; mushroom spawn." This category is mainly imported into the Bahamas from the United States (**Table 8.2**). Of the category "trees, shrubs and bushes, of kinds which bear edible fruit or nuts," approximately 2 million plant units were imported into the GCR in 2007, mainly into Colombia (from the United States, Israel, Argentina, and Chile), Guatemala (from Honduras, Costa Rica, Mexico, and the Netherlands), and the Bahamas (from the United States) (**Table 8.3**). Less frequently imported categories of propagative materials were: “roses, including their roots” (**Table 8.4**), “azaleas and rhododendrons, including their roots” (**Table 8.5**), and “unrooted cuttings and slips” (**Table 8.6**) (UNComtrade, 2008).

The United States maintains a database of plant genera imported. Unfortunately, the data is not reported in consistent units of measurement, making quantitative comparisons impossible. In 2007, nearly 800 different plant genera were imported into the United States from 21 countries of the GCR (USDA, 2008e), mainly from Costa Rica, Guatemala, and Colombia (**Table 8.7**).[14] Because the database lists only the genera and not the species of propagative materials imported, a discussion of the potential risk posed by these imports is difficult.

In general, any plant species imported may present a phytosanitary problem in two ways: 1) by introducing exotic plant pests, and 2) by itself becoming an invasive weed in its introduced range.

Propagative Material as a Pathway for Plant Pests

Infested or infected propagative material is often considered to be one of the primary means through which plant pests and pathogens invade new areas (Palm and Rossman, 2003). Pests that are introduced on propagative material have the advantage of being moved together with a suitable host plant. In addition, the propagative material is usually planted in a climate conducive to its growth, and the same climate is also likely to be suitable for its associated pests. Furthermore, the plants are often planted in groups or even large monocultures, thereby providing ideal conditions for a pest population to grow and expand.

Numerous important plant pests are known to have been introduced to new locations on propagative material. *Metamasius callizona* (Coleoptera: Dryophthoridae), a weevil native to Mexico and Central America, was introduced on bromeliads into Florida, where it now threatens populations of native bromeliads (Frank and McCoy, 1995). As a direct result of the damage caused by *M. callizona*, the Florida Endangered Plant Advisory Council added two species of bromeliads to its list of endangered species (Larson and Frank, 2007).

The citrus longhorned beetle, *Anoplophora chinensis* (Coleoptera: Cerambycidae), was recently detected in Germany when 100,000 potted Japanese maple, *Acer palmatum* (Aceraceae), trees from China were sold throughout the country by a supermarket chain (Deutsche Welle, 2008). *Anoplophora chinensis* is a pest of trees and shrubs from 26 families, including citrus and other fruit trees in China. Native to Asia, it has spread to other areas of the world, including tropical Oceania (GPDD, 2009); thus, this beetle may also be able to establish in the GCR if introduced.

[14] Costa Rica exports annually about $30 million worth of ornamental plants - more than half of its yearly total - to the United States WTO. 2007. Clean stock program for *Dracaena* spp. intended for export to the United States. World Trade Organization..

Cowie *et al.* (2008) implicate the horticultural industry as a pathway for the spread of terrestrial mollusks. In a survey of nurseries in Hawaii, they found 29 introduced species (belonging to 24 families) of terrestrial snails and slugs, five of them previously unrecorded. As these species originated from all around the world, the authors speculate that the Hawaiian situation may be representative of the horticultural snail and slug faunas of many other tropical regions. The potential economic and ecological impact of terrestrial mollusks is largely unknown, but there are reports of introduced slugs reducing seedling survival of endangered plants in Hawaii (Joe and Daehler, 2008), of exotic snails outcompeting native species (Halwart, 1994, Wood *et al.*, 2005), destroying native vegetation (Carlsson *et al.*, 2004) in Asia, and causing crop damage (Mead, 1961).

In 2003, Childers and Rodrigues (2005) sampled 24 plant shipments (cuttings or rooted plants) entering the United States from Costa Rica, Honduras, and Guatemala and found half of the shipments infested with mites. In total, they detected 81 mite species belonging to 11 different families. Mites can vector plant viruses, such as citrus leprosis virus, coffee ringspot virus, passion fruit green spot virus, ligustrum ringspot virus, and orchid fleck virus (Miranda *et al.*, 2007). There are numerous viruses not yet present throughout the GCR that could cause significant economic damage if introduced and spread within the GCR by mites occurring there (CABI, 2007).

On several occasions, *Ralstonia solanacearum* race 3 biovar 2 (Burkholderiales), a bacterial pathogen, was found in geranium cuttings shipped from a commercial greenhouses in Guatemala and Kenya to the United States for rooting and sale (USDA, 2004, 2008c). Also, in the United States, many new powdery mildew diseases have appeared over a relatively short period of time, and it is suspected that they were introduced on plant cuttings (Palm and Rossman, 2003). For example, poinsettia powdery mildew may have gained entry into the United States through the importation of infected un-rooted cuttings (Palm and Rossman, 2003).

During 2007, 1,541 specimens of reportable pests (**Table 8.8**) were intercepted at U.S. ports of entry in commercial shipments of propagative material from the GCR, showing that significant numbers of pests move in association with propagative material (USDA, 2008d).

To prevent the introduction of pests through the propagative material pathway, GCR countries have implemented certain safeguards. While specific regulations vary, most countries require an import permit, phytosanitary certificate, freedom from soil, and port-of-entry inspection for propagative materials (IPPC, 2008). The specific procedures for issuing phytosanitary certificates vary between countries, and the reliability or adequacy of these procedures may be low in some cases.

Major producers of plants also implement their own safeguards to protect their investments. For example, certain sanitary procedures, such as washing hands, disinfecting shoes, cleaning tools, sterilizing soil, sampling for pests, and routine diagnostic tests for certain pathogens are standard in large greenhouse production

(Meissner and Schwartzburg, 2008). It is not uncommon for major producers to employ highly-qualified subject matter experts who are very familiar with the products and their associated pests. Because the sale of diseased or pest-infested plants is not a good business practice, and the rejection of plant shipments at the border is very costly to the producer, companies have a strong interest in keeping their plants pest-free. However, smaller producers may not have the financial means or the expertise to achieve high levels of sanitation, and some companies may be more interested in short-term profits than long-term benefits.

In general, there is heavy reliance on inspection, either as a condition for entry or for export certification. This is problematic because there is abundant evidence that inspection is not effective in preventing unwanted pest introductions. Brodel (2003) pointed out that only about a quarter of the pests that established in Florida during 1997 and 1998 had been intercepted more than once at U.S. ports of entry prior to their establishment.

While Childers and Rodrigues (2005) detected 81 mite species representing 11 different families on only 24 shipments of propagative materials, port-of-entry inspections in Miami have led to a mere 265 mite interceptions out of over 40,000 propagative material shipments[15]; all of these mites were identified as members of a single family, Tetranychidae. This shows that, in spite of best efforts, port-of-entry inspection misses the overwhelming majority of mites and presumably most other types of minute organisms associated with propagative materials. In addition, the taxonomic diversity of the interception records in no way reflects the actual diversity of mites present on the commodities.

If mites are underrepresented in port of entry inspections, plant pathogens are virtually ignored. Pest interceptions in Miami on propagative materials from anywhere in the GCR during 2007[16] included 1,285 interceptions (33 families) of insects and 167 interceptions (5 families) of mollusks. In contrast, nematodes were detected only once, and fungi were intercepted a mere 39 times (≤17 species), whereas no interceptions of viruses, bacteria, or phytoplasmas were recorded.

This is in stark contrast to the immense diversity and abundance of plant pathogens in the world. An estimated 10,000 known species of fungi cause plant diseases worldwide (Agrios, 2005) and perhaps only 10 percent of all existing fungi have been described (Palm and Rossman, 2003). An international working group estimated the number of fungal species (not limited to plant pathogenic species) in the Guanacaste Conservation Area in Costa Rica to be around 50,000 and that an inventory would cost $10-30 million dollars and take 7 years to complete (Hawksworth and Mueller, 2005).

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[15] Interceptions on propagative materials (plants and cuttings) imported from Costa Rica, Guatemala and Honduras during 2007. Data from 2007 was used because import data was incomplete for 2003, which is when sampling by Childers and Rodriguez (2005) took place.

[16] Ca. 42,000 shipments

Similarly, over 1,000 viruses are known to attack plants, and new viruses are described every month (Agrios, 2005). Some 60% of plants surveyed in a Costa Rican region containing about 7,000 plant species total were positive for double-stranded RNA, a marker suggesting the presence of viruses (Wren *et al*., 2006).

Several hundred species of nematodes and over 100 species of bacteria are known to cause plant diseases. In addition, about 40 plant diseases are known to be caused by viroids, and over 200 plant diseases are caused by phytoplasmas (Agrios, 2005).

Why do port-of-entry inspections miss so many pests? The reasons for this are manifold, including overwhelming workload, pressure to perform inspections quickly, difficulty of detecting certain types of pests, inadequate working conditions (*e.g.,* lighting, space), insufficient training of inspectors, and lack of tools such as magnifying lenses, microscopes, and diagnostic tests. Depending on the country, some of these reasons may be more important than others.

Minute and hidden organisms are notoriously difficult to detect, and pathogens are especially likely to escape detection (Schaad *et al*., 2003). Visual inspection for pathogens relies on the expression of symptoms in the infected plants. However, it is not uncommon for infected plants, and especially seeds, to be asymptomatic during a certain time or under certain circumstances (Lanterman *et al*., 1995, Palm and Rossman, 2003), and symptomless hosts exist for many pathogens. In these cases, detection requires diagnostic tests.

Appropriate diagnostic tools exist only for a relatively small number of pathogens and are often not affordable or feasible for plant quarantine purposes (Schaad *et al*., 2003). Another limiting factor is the amount of time it takes to perform certain tests, which could delay shipments for unacceptable lengths of time at ports-of-entry. Even PCR-based detection protocols, which are available for certain pathogens and allow for a diagnosis to be made within a day or less (Schaad *et al*., 2003) are often not fast enough. Nucleic acid-based procedures are not optimal for large-scale diagnostic purposes because of expense and complexity (Lanterman *et al*., 1995).

Given the wide variety of propagative material that can be imported, even knowing which pathogens to screen for is difficult. Serological diagnostic techniques require that the causal agent has been described and characterized (Schaad *et al*., 2003); however, the vast majority of plant pathogens have not yet been described, and new disease-causing organisms are discovered all the time (Palm and Rossman, 2003). Kairo *et al.* (2003) noted that the number of microorganisms reported introduced in the insular Caribbean region is negligible, indicating a knowledge gap in species inventory.

To make matters worse, species of plant pathogens tend to be subdivided into strains, biovars, pathovars, *etc*., which can differ in their infection capabilities and host range. Palm and Rossman (2003) raised the argument that a species of pathogen should not be considered “low risk” after it has established in an area, given that strains of that species may still exist that are exotic to the area and may behave very differently from the one that is established. Regulating strains and races of plant pathogens is difficult because differentiation from already present strains requires molecular techniques (Palm and Rossman, 2003).

Smuggling of propagative material bypasses established phytosanitary safeguards. For example, in 2004, citrus budwood cuttings were intercepted in mail packages arriving in the United States. The packages, destined for a citrus growing area in California, were labeled on the shipment manifest as "books and chocolates." One of the shipments tested positive for *Xanthomonas axonopodis* pv. *citri*, the causal agent of citrus canker (CBP, 2005). Upon further investigation, several thousand citrus cuttings that had been smuggled into the country were found on various private properties. In 2008, narcissus bulbs from China contaminated with soil were found in a wholesale market in the United States. Upon further investigation, it was discovered that the bulbs entered without the proper certification and inspection; they had been labeled on the import documents as ceramic pots. A total of 590 pounds of contaminated narcissus were seized and destroyed (SITC, 2008). Also in 2008, 19 pounds of containerized *Crocosmia* spp. plants with soil, manifested as a cappuccino machine and 4 cups/saucers, were intercepted at an international mail facility in the United States. These plants are prohibited and lacked a phytosanitary certificate (SITC, 2008).

In summary, it is obvious that pests, and especially plant pathogens, are spreading between countries through both legal and illegal movement of propagative materials. This is occurring on a global scale. About 50 new disease locations or disease-host associations were reported during 2008 in the journal *New Disease Reports* alone. Apart from severe restrictions on the importation of propagative materials, there is no easy solution to this problem.

Plant Propagative Material as Invasive Species

In addition to serving as a pathway for pest introductions, propagative material may itself become invasive in its introduced range.

Consumer demand drives the continued importation of new plant species and varieties. In Florida alone, over 25,000 exotic plant species are grown in cultivation (Frank and McCoy, 1995). Some commercial nurseries engage in plant exploration, the search for new plant material to develop cultivars, new crops, or novel ways to utilize a plant. In order to recoup costs, they must propagate and sell the specimens quickly (Reichard and White, 2001). Botanical gardens and arboreta also actively introduce new plants, often distributing propagules to other horticultural groups or the general public (Reichard and White, 2001, Dawson *et al.*, 2008). Private plant collectors actively (and often illegally) introduce plants from foreign countries. For example, people of Martinique have been known to bring back rare plants for their gardens from Guyana and Guadeloupe (Iotti, 2008).

There are numerous botanical gardens in the GCR (Gutierrez Misas, 2005), most of which feature exotic plants. These gardens not only serve as an entry point for invasions (Dawson *et al.*, 2008), but they may also be promoting exotics in the local community directly and indirectly (*e.g.*, (FTG, 2007)). A recent publication about the role of botanic gardens in plant invasions states that a screening approach for invasiveness has yet to be applied in tropical botanic gardens (Dawson *et al.*, 2008).

While many introduced plants do not become problematic, a certain percentage do become invasive (Williamson and Fitter, 1996). Of 220 tree species known to have been intentionally introduced into the GCR, at least 179 have established in the wild, many of them growing invasively (Kairo *et al.*, 2003).

The large majority of invasive exotic plant species were intentionally introduced. Waugh (2008) reviewed the published literature for invasive species in the insular Caribbean and estimated that of the 191 invasive plants examined, 66 percent were introduced deliberately to the insular Caribbean through the horticultural pathway. The Bahamas National Biodiversity Strategies and Action Plan states "alien plants have been introduced with little control […] mainly by gardeners and horticulturalists" (BEST, 2003). Frank and McCoy (1995) reported that about one quarter of Florida's flora is comprised of non-indigenous species, almost all of them introduced deliberately.

Among the worst weeds of Florida are the punk tree, *Melaleuca quinquenervia* (Myrtaceae), introduced to drain wetlands, Australian pine, *Casuarinas equisetifolia* (Casuarinaceae), introduced as an ornamental, as well as Brazilian pepper, *Schinus terebinthifolius* (Anacardiaceae), and cogon grass, *Imperata cylindrica* (Poaceae), both introduced deliberately (Frank and McCoy, 1995). Kudzu, *Pueraria montana* var. *lobata* (Fabaceae), introduced into the United States for erosion control and strongly promoted as a forage crop and ornamental plant, has become one of the most serious invasive weeds in the southeastern United States (DCR, 1999).

Over 60 *Ficus* (fig) species have been introduced into southern Florida as ornamentals. Because *Ficus* are pollinated by species-specific agaonid wasps, it is generally assumed that they are not able to set fruit outside of their native range. However, the pollinators of three *Ficus* species in Florida have been accidentally introduced, leading to the spread of these *Ficus* species in two Florida counties (Frank and McCoy, 1995).

In Barbados, sweet lime, *Triphasia trifolia* (Rutaceae), and mother-in-law's tongue, *Sansevieria hyacinthoides* (Agavaceae), are both garden escapes that have replaced shrub layers in forested gullies (Waugh, 2008). The neem tree, *Azadirachta indica* (Meliaceae), introduced for the purpose of reforestation, has become an invasive species throughout the Dominican Republic, as well as Puerto Rico and Antigua and Barbuda (IABIN, 2008). Mock orange, *Pittosporum undulatum* (Pittosporaceae), spread from the Cinchona Botanic Gardens in Jamaica and from other points where it was planted as an ornamental tree species; wild ginger, *Hedychium gardneranum* (Zingiberaceae), and redbush, *Polygonum chinense* (Polygonaceae), were also introduced through the botanic garden

(Waugh, 2008) [17]. In the Bahamas, "tree species, such as *Casuarina*, *Melaleuca*, and *Schinus*, are aggressive invaders of forests, wetlands and disturbed or open sites, displacing native plant species." (Waugh, 2008).

Kairo *et al.* (2003) lists the following tree species as naturalized and/or invasive in at least five countries of the GCR, thus considering them major invasive threats to the region: the red beadtree, *Adenanthera pavonina* (Fabaceae); woman's tongue, *Albizia lebbeck* (Fabaceae); beach sheok, *Casuarina equisetifolia* (Casuarinaceae); white cedar, *Tabebuia heterophylla* (Bignoniaceae); and Indian jujube, *Ziziphus mauritiana* (Rhamnaceae). Common water hyacinth, *Eichhornia crassipes* (Pontederiaceae), an aquatic plant, is also identified as a major invasive threat to the insular Caribbean (Kairo *et al.*, 2003) and is classified as a U.S. noxious weed (USDA, 2008b). Annual costs to control this weed in seven African countries are between $20-50 million/year (McNeely, 1999).

In the United States, invasive plants currently infest an estimated 40 million hectares, and continue to spread into an additional 1.2 million hectares every year (NISC, 2001). Invasive plants have seriously degraded more than 15 million hectares of grazing lands and natural ecosystems in Australia (Glanznig, 2003). Noxious weeds have invaded an estimated 10 million hectares in South Africa (van Wilgen *et al.*, 2001), where they are appropriating as many as 3.3 billion m^3 (7%) of mean annual surface water runoff from catchments, riparian zones, and wetlands (Olckers, 1999).

Economic losses due to introduced plants surpass those caused by any other class of invasive species. For example, the annual economic impact of invasive weeds is estimated to be approximately $39 billion in India, $34 billion in the United States, $17 billion in Brazil, $1.4 billion in the United Kingdom (Pimentel *et al*., 2001), $12 billion in South Africa (van Wilgen *et al.*, 2001), $3 billion in Australia (Sinden *et al*., 2004), and $1 billion in New Zealand (Williams and Timmins, 2002). Losses to the Canadian economy resulting from invasion by four weeds, *Cirsium arvense*, *Centaurea diffusa*, and *Centaurea maculosa* (Asteraceae) and *Euphorbia esula* (Euphorbiaceae), exceed $250 million annually (Claudi, 2002).

What safeguards are in place to prevent additional introductions of invasive plants? Unfortunately, the safeguards are few and insufficient for most countries of the GCR, including the United States.

A review of the phytosanitary laws of the GCR countries showed that most regulations regarding propagative materials aim at preventing the introduction of pests associated with the plants, but are not concerned with the invasiveness potential of the plants themselves. For example, many countries require phytosanitary certificates, inspection, and freedom from soil, but to the best of our knowledge none require weed risk assessments as a condition for import. The regulated pest list of most countries either

[17] Waugh (2008) cites the following reference: Goodland, T. and J. R. Healy. 1996. The invasion of Jamaican montane rainforests by the Australian tree *Pittosporum undulatum*. School of Agricultural and Forest Sciences, University of Wales, Bangor, UK.

contains no weeds at all or lists only a relatively small number of plants, which tend to be agricultural weeds not likely to be imported as propagative materials (IPPC, 2008).

The United States generally allows the importation of any plant species, except for a number of regulated species and families. Most of these can still enter with an import permit or after certain treatment requirements have been fulfilled. Very few species are absolutely prohibited. Paradoxically, weed risk assessment, a necessary condition for the importation of fruits and vegetables, is not required for the importation of live plants that are intended for planting and propagation. Thus, plants that are known to be notorious invaders elsewhere in the world can be legally imported, sold and distributed within the United States. Tschanz and Lehtonen (2005) proposed actions to address these risks, and plans are currently underway to develop legislation that establishes a new category of nursery stock, plants that are "not authorized for import pending risk analysis (NAPPRA)" (USDA-APHIS, 2009).

Costa Rica's regulations contain a detailed list of plant species for which importation is permitted, specifying requirements by country of origin (IPPC, 2008). Again, plant pests other than the commodity itself are the target of these regulations. Examples of plant species explicitly permitted to enter include: *Ziziphus mauritania* (Rhamnaceae), named a major invasive threat to the GCR by Kairo *et al.* (2003); *Pittosporum undulatum* (Pittosporaceae), an economically important invasive species in Jamaica (Kairo *et al.*, 2003); *Hedychium* spp. (Zingiberaceae) and Ficus spp. (Moraceae). *Hedychium gardneranum* is invasive in Jamaica (ISSG, 2008), and several *Ficus* species are invasive in tropical parts of the world (Yoshioka, 2009).

Even in cases where proper regulations are in place, effective safeguarding may be hindered by the difficulty of identifying propagative material to the species level. The immense variety of plant material entering from all over the world easily overwhelms any level of diagnostic expertise. In addition, the growth stage and condition (seeds, cuttings without leaves, *etc.*) of the plant material complicates identification. Thus, if shipment manifests or phytosanitary certificates provide incorrect information, phytosanitary officers may not be able to detect the error, and prohibited species may be allowed to enter.

The issue of smuggling, already discussed in the previous section, is again of concern here. Literature on the illegal trade of plants is limited. Flores-Palacios and Valencia-Díaz (2007) conducted a study in Mexico to quantify illegal trade of epiphytes and measure the diversity of species sold. Visiting a local market, they found that the illegal trade of epiphytes (species belonging to the Orchidaceae, Bromeliaceae, and other plant families) is high and occurs regularly, despite being illegal. Over an 85-week period, they counted the illegal sale of 7,598 plants or cuttings, equaling the volume of legal orchid exports from Mexico (Flores-Palacios and Valencia-Díaz, 2007). While this study was conducted in Mexico, there is no reason to believe that the situation would be different in many countries of the GCR.

In 2001, dozens of horticultural groups worldwide drafted and adopted the St. Louis Codes of Conduct as a voluntary measure to "curb the use and distribution of invasive plant species through self-governance and self-regulation by the groups concerned" (Baskin, 2002, CPC, 2008). Representatives from government, industry, and botanic gardens agreed that a screening system was needed to identify potentially invasive plant species before they are imported into the country (Reichard, 2004). However, despite continued recognition of this important pathway (Burt *et al.*, 2007, Dawson *et al.*, 2008), to our knowledge only one botanic garden has developed a screening procedure for invasive weeds (*e.g.*, (Jefferson *et al.*, 2004)).

In summary, the propagative material pathway allows invasive plants to continuously enter countries of the GCR, where they often cause considerable economic and environmental damage. There are essentially no safeguards in place to prevent this from happening.

Recommendations

- **Require a weed risk assessment for the importation of plant species.** Prohibit the importation of all plant species unless they have been deemed unlikely to become invasive by a (predictive) weed risk assessment. Any country without this policy leaves a weakness in its safeguarding system. (Exceptions may be made for plants that have been historically imported at high volumes.) The Australian Weed Risk Assessment system is the most widely known and tested system of its kind (Gordon *et al.*, 2008).

- **Assess the invasiveness of plant species retrospectively** (*e.g.*, (Heffernan *et al.*, 2001, Fox *et al.*, 2005, Randall *et al.*, 2008). Retrospective assessments evaluate the invasiveness of plants some time after they have been imported. Retrospective assessments are important because a lag time may exist between species introduction and onset of invasiveness, invasiveness may change due to environmental changes, or the invasiveness potential of a species may have been misjudged in a predictive weed risk assessment (Reichard and White, 2001).

- **Draft a voluntary code of conduct for nurseries and landscaping businesses** to promote the sale and use of native and non-invasive plants. This code of conduct should stipulate that the businesses:
  - ensure that their staff is knowledgeable on the subject of invasive plants
  - help educate their customers about invasive plants
  - refrain from selling or planting species that are known to be invasive
  - clearly label native plants and foreign non-invasive plants
  - immediately report any potentially exotic pest organisms found on imported plants

- ❖ **Draft a voluntary code of conduct for local governments, resorts, hotels, and other entities that engage in large-scale landscaping.** This code of conduct should stipulate that the entities:
  - o plant only native species or foreign species known to be non-invasive
  - o remove plants that are becoming invasive
  - o help educate their customers/residents on invasive plants

- ❖ **Draft a voluntary code of conduct for botanical gardens and arboreta.** Conclusions from the first World Botanic Gardens Congress state that "Botanic gardens and arboreta have, and continue to, contribute to this problem by promoting actually and potentially invasive plants. Botanic gardens and arboreta have a clear responsibility to adopt and demonstrate to the public a strong environmental ethic" (BGCI 2000). Code of conduct should stipulate that botanical gardens:
  - o conduct invasiveness studies prior to introducing a new plant into botanic gardens, arboreta, and the landscape. Possibly model invasiveness evaluation after systems already in place at some botanic gardens that currently have evaluation systems in place (BGCI, 2000)
  - o re-evaluate current plant collections for invasiveness (BGCI, 2000)
  - o …"engage and educate fellow botanic gardens and arboreta, the horticulture industry, and the public about the importance of choosing and displaying ecologically responsible plant collections." (BGCI, 2000)
  - o "support, contribute to, and share research that identifies problems and provides solutions" related to invasive plant species." (BGCI, 2000)

- ❖ **Develop an educational program on identification and potential impact of invasive plant species in the GCR** (Reichard and White, 2001, Waugh, 2008). This program should target the general public, as well as businesses and governments throughout the GCR. The program may be developed at universities, for example through graduate student projects.

- **Develop a certification process** that allows any entity adhering to the above-mentioned codes of conduct to become a "Certified Ambassador of Invasive Species Prevention."

- **Develop sampling protocol for mites and other small arthropods.** "Visual inspection for mite infestations on large numbers of plants is inadequate […]… A sampling protocol […] would include a designated subsample of plants in a shipment. Use of either an 80% ethanol wash or a specified concentration of detergent solution would be employed […]. This assessment should be done for a minimum period of one year to identify trends and seasonal patterns of different pest mite species (as well as other arthropods) and provide assurance of compliance by foreign shippers." (Childers and Rodrigues 2005).

- **Increase attention to plant pathogens.** As much as feasible, increase the availability of molecular diagnostics. Develop a list of common pathogens of economic importance for which plant material should be tested on a regular basis. Share test results within the GCR. Use early warning and bio-surveillance systems as inputs for decision making.

- **Require phytosanitary certificates for all imports of propagative materials.** The phytosantairy certificates should indicate the species and, if applicable the variety, of the imported plants and should provide some assurance that the plant material is free of pests based on *clearly specified* inspection protocols.

- **Evaluate adequacy and reliability of procedures for issuing phytosanitary certificates.** Can the phytosanitary certificates be generally trusted? Is the staff providing the information qualified? What is the affiliation of the persons providing the information (NPPO, industry, *etc.*)? Are specific inspection guidelines in place? Is there a mechanism for error control? Is there effective communication between the importing and the exporting country?

- **Support the efforts of the IPPC to develop an international standard for plants for planting.** "International trade in plants for planting has a high potential for the introduction of regulated pests. Current phytosanitary measures that rely mainly on treatments and inspections are, in some cases, inadequate to mitigate the risks. Harmonized procedures for phytosanitary security of traded plants for planting are necessary to allow increased trade while minimizing phytosanitary risks and unnecessary delays. The expert working group is tasked with drafting a standard that will outline the main criteria for the identification and application of phytosanitary measures for the production and international movement of plants for planting (excluding seeds), while also providing guidance to help identify and categorize the risks." (IPPC, 2008)

- **Record information on propagative material imported** by plant species, with information on variety, type of material (roots, cuttings, *etc.*), country of origin, growing and inspection practices followed, date of importation, and amount imported in consistent units.

- *In the United States:* **Give strong priority to the improvement of "quarantine 37"**, building on the recommendations of Tschanz and Lehtonen (2005). If necessary, divert scientific, risk analysis, and regulatory resources away from fruit and vegetable towards propagative material imports.

- **Implement systematic data collection efforts** to assess the pest risk associated with at least the most common imports of propagative materials. These data collection efforts should be based on a statistically sound sampling scheme (validated by a qualified statistician) and should follow a clearly documented inspection protocol. This protocol should describe in detail the inspection methods to be followed (*e.g.*, detergent wash, diagnostic tests for pathogens, use of hand lens, *etc.*). Consider making resources available to fund this work as graduate student research. The advantages of this approach over using port-of-entry personnel would include: lower cost, less diversion of inspectors, more objectivity and reliability of research, and better distribution and documentation of results through the scientific publication process.

- **Develop a systems approach** to reduce the pest risk associated with the propagative materials that pose the highest risk of pest introduction. The systems approach should be customized for each commodity and should be developed collaboratively by the importing and the exporting countries. The systems approach may contain components such as scouting, pesticide applications, biological control, reduction of fertilizer levels, routine diagnostic tests for pathogens, basic sanitation practices (*e.g.*, washing of shoes and equipment, *etc.*), pre-shipment inspection, quarantine treatments, *etc.* The systems approach developed for Costa Rican *Dracaena* plants for importation into the United States may serve as one example of a potentially very successful and mutually beneficial program.

Chapter 9: Natural Spread

Introduction

The spread of exotic organisms throughout the Greater Caribbean Region (GCR) is strongly facilitated by trade and travel. Nevertheless, that natural spread, mediated by wind, may also play a significant role seems to be a logical assumption given the close proximity of adjacent islands, the separation of Florida from Cuba by less than 150 km, the separation of Cuba from Mexico by about 250 km, and the separation of Trinidad from Venezuela by only 10 km.

The objective of this chapter is to provide a short review of the scientific literature with regard to the following questions:

- Does natural spread of pests occur into and within the GCR?
- What are the prevailing spatial and temporal patterns of natural spread?
- What types of pests are most prone to disperse by natural spread?

Does natural spread occur into and within the GCR?

In most cases, it is impossible to determine the pathway through which a pest was introduced; thus, examples of known pest introductions via natural spread are rare.

The fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae), migrates every year from the Caribbean islands (Puerto Rico, U.S. Virgin Islands, Guadeloupe, and French Guiana), where it occurs year-round, into the United States. Pheromone trapping of adult moths and wind current analysis indicated seasonal migration between the Antilles and the continental United States and between the United States and Canada (Mitchell *et al.*, 1991). The distance of single flights of the adult moths of *S. frugiperda* depend upon prevailing winds, temperature, and food supply at the time of the flight (Luginbill, 1928).

Frank and McCoy (1995) list six butterfly species that are believed to periodically recolonize Florida from Cuba via wind-assisted flight: *Chlorostrymon maesites, Strymon acis, Eumaeus atala* (Lycaenidae)*; Eunica tatila, Anaea troglodyte* (Nymphalidae)*;* and *Heraclides aristrodemus* (Papilionidae).

Operating insect traps on unmanned oil platforms in the Gulf of Mexico at 32, 74, 106, and 160 km from the Louisiana shoreline, Sparks *et al.* (1986) collected 177 species of insects over 40 days. The insects represented 69 families belonging to the following orders: Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Odonata, Orthoptera, and Trichoptera.
Close *et al.* (1978) trapped several species of insects over the ocean at distances of up to 3,000 km from land.

The first detection of the red palm mite, *Raoiella indica* (Acari: Tenuipalpidae), in the Western Hemisphere occured in Martinique in 2004. Within a year, the pest appeared on nearby islands.

Even though human-mediated movement was an important mechanism in the subsequent spread of this pest throughout the GCR, the presence of *R. indica* populations on very tall and mature coconut palms in St. Lucia also suggests wind currents as a mode of spread (Hoy *et al.*, 2006).

Locust swarms from the Cape Verdes region in Africa reached the Caribbean islands in 1988 (Richardson and Nemeth, 1991); however, the insects were weak and did not establish populations in the GCR (Richardson and Nemeth, 1991).

The Asian citrus canker bacterium, *Xanthomonas axonopodis* pv. *citri* (Xanthomonadales: Xanthomonadaceae) was detected in 1995 on citrus trees near Miami International Airport (Gottwald *et al.*, 1997). Disease spread is closely linked to weather events; after hurricanes Charley, Francis, and Jeanne in 2004, its distribution increased by 80,000 acres of commercial citrus, and after hurricane Wilma in 2005, its distribution increased by yet another 200,000 acres.

Similarly, bean golden mosaic virus (BGMV), widespread throughout large parts of the Greater Caribbean Basin by 1990 (Brunt *et al.*, 1990) appeared in south Florida immediately after the passage of Hurricane Andrew in 1992 (Blair *et al.*, 1995).

Thomas (2000) showed that only a small percent of the exotic arthropods in Florida originated in Africa, with the majority coming from Asia, the Pacific, and the Neotropics. This suggests that *long-distance* natural spread of plant pests *into* the GCR may be less important than transport through trade and tourism. However, given the evidence listed above, some degree of wind-assisted natural spread is probably occurring on an on-going basis.

What are the prevailing spatial and temporal patterns of natural spread in the GCR?

The history of the Caribbean islands has been strongly influenced by the continuous flow of the trade winds that blow at a steady 15 to 25 knots (Rogozinski, 1999) from the coast of Africa across most of the GCR. Part of the year, the winds move in a clockwise rotation (**Figure 9.1**) through the GCR, favoring the wind-mediated movement of pests northward from Venezuela as opposed to southward from Florida. Virtually all plant and animal life on the Caribbean islands have migrated from east to west—from the northern coast of Venezuela to Trinidad, up through the Lesser Antilles and Virgin Islands, and then across the Greater Antilles, *i.e.*, to Puerto Rico, Hispaniola, Jamaica, and Cuba (Rogozinski, 1999). It is therefore likely that the natural spread of newly introduced pests would follow this same path.

The tropical trade winds carry the African dust from June through October toward the North/Central Caribbean and the Southeastern United States. From November through May, the shift in winds carries the dust toward the South Caribbean and South America (Griffin *et al.*, 2003). The dust clouds cross the Atlantic in five to seven days and are visible via satellite imagery and to the naked eye (Griffin *et al.*, 2003). If dust can be transported in this way, then it is conceivable that certain organisms, such as fungal spores or insects may be transported, as well.

In addition to the general direction set by the prevailing trade winds, the **s**ea-breeze circulation, consisting of an afternoon sea-to-shore and a nocturnal land-to-sea surface wind also may have an influence on the movement of air-borne pests. By means of Doppler radar, Russell and Wilson (1996) found that concentrations of weak-flying insects near the Atlantic coast of Florida were dispersed inland on the sea breeze, while Sauvageot and Despaux (1996) reported that the evening land-to-sea breeze at the coast of France was responsible for carrying small insects from land out over the Atlantic.

Once over land, pest movement may also be directed by the diurnal cycle of local winds between low and high altitude areas. During the daytime, winds tend to blow from the coastal plain toward the mountain, and at night from the mountain toward the coastal plain. The mountain-plains wind system is most apparent on days when the general prevailing winds are weak. The upslope winds in valleys are often 3-5 m s^{-1} (6.7 -11.1 mph). Such local winds on and near Caribbean islands probably help to launch some insects on flights over the sea, as well as to aid insects arriving from across the sea to disperse well into the interior of the island.

Tropical storms (winds of 39 to 73 miles per hour) and hurricanes (winds of 74 miles per hour or greater) can form at any time between the beginning of June to the end of November, but more than 80 percent develop during August, September, and October (Rogozinski, 1999). An average of about 15 tropical cyclones, including seven or eight hurricanes, occur per year, though many never reach land (Rogozinski, 1999, Quantick, 2001).

Hurricanes affecting the GCR arise primarily near the Cape Verde Islands off the coast of West Africa or off the coasts of Honduras and the Yucatán Peninsula in the eastern Caribbean Sea (Quantick, 2001). The course of hurricanes is unpredictable, but most tend to travel slowly, at about 10 miles per hour, across the Lesser Antilles or Greater Antilles (Rogozinski, 1999). Early-season hurricanes (July-August) usually hit the Lesser Antilles, while late-season hurricanes (September-October), tend to be more severe and have a more northerly track that passes over the Greater Antilles (Caviedes, 1991) (**Figure 9.2**). They may curve to the north or northeast, either striking the southeastern coast of the United States or dying out in the middle of the Atlantic Ocean. Only Trinidad and three islands off of Venezuela are far enough to the south of a typical hurricane's path to be safe from destruction (Rogozinski, 1999).

In summary, natural spread of pests within the GCR, is most likely to occur from Venezuela to Trinidad, up through the Lesser Antilles and Virgin Islands, and then across the Greater Antilles. It is not very likely to occur in the opposite direction. In addition, wind promotes the movement between land and sea, as well as between lower and higher altitudes. As the direction of these movements depends on the time of day, it may affect different pests in different ways, depending on their diurnal rhythm of activity. Tropical storms and hurricanes, which can also spread pests, are common in the GCR, occuring most frequently in late summer to fall. Their paths are unpredictable, but tend to move from east to west into the GCR and then may curve back towards the east or northeast.

What types of pests are most prone to disperse by natural spread?

Minute arthropods: mites, scales, aphids, thrips, collembola

Minute arthropods generally are not capable of covering long distances by active flight. They are, however, transported passively over sometimes large distances by wind currents.

Mites, being wingless, cannot engage in active flight, but they do exhibit behavioral adaptations that facilitate passive aerial dispersal. For example, the cassava green mite, *Mononychellus tanajoa* (Acari: Tetranychidae), and other spider mites disperse aerially by climbing to the top of a plant, producing a silken thread and "spinning" from the edge of a leaf before being carried away by the breeze (Yaninek, 1988).

Immature scale insects, also known as crawlers, and mealybugs are similar in their ability to move on wind. These types of insects generally move from plant to plant by aerial dispersal~~,~~ (Yaninek, 1988). Though generally, aerial dispersal of spider mites, mealybug and scale crawlers covers distances of less than 10 km/year (Yaninek, 1988), there are accounts of coccids that appear to have been carried across the Tasman Sea from Australia to New Zealand during appropriate meteorological conditions (Close *et al.*, 1978, Drake and Farrow, 1988).

For alate aphids, take-off is an active process, but once airborne, aphids are carried passively by the wind. Aphids have been transported by wind over distances up to at least 800 miles (Schneider, 1962). Within the laboratory, aphids can remain aloft for up to 12 hours (Wiktelius, 1984), and studies under natural conditions show an average flight duration of two to three hours (Wiktelius, 1984). Some aphids (Hemiptera: Aphididae) routinely engage in long-distance migrations, e.g. the English grain aphid, *Macrosiphum avenae*, the corn leaf aphid, *Rhopalosiphum maidis*, the bird cherry-oat aphid, *Rhopalosiphum padi*, and the greenbug, *Schizaphis graminum* (Johnson, 1995).

Mass flights of some thrips species, such as the western flower thrips, *Frankliniella occidentalis* (Thysanoptera: Thripidae), are triggered by the senescence and death of the flowers on their host plants (Ramachandran *et al.*, 2001). Thrips are known to be passively borne long distances in wind currents (Lewis, 1973, Laughlin, 1977, Lewis, 1997).

Small soil-surface-active insects such as Collembola may be swept up into the air. Wind-blown Collembola and mites have been collected in suspended plankton nets at altitudes of 1500 m (Coulson *et al.*, 2003).

Minute arthropods are susceptible to dessication during flight. For example, a study in southern Australia (Laughlin, 1977) revealed that in an ambient temperature of 10-14º C, thrips could survive in the air without food or water for over 24 hours, while at summer temperatures of approximately 19-23º C, survival times of airborne thrips were predicted to average six hours, and on very hot days only three hours. Though minute arthropods may have a small chance of surviving transport over very large distances, they may easily be able to survive travel over short distances, such as between adjacent islands.

Larger insects: moths, butterflies, leafhoppers

Lepidopterans –at least the larger species- are generally strong enough fliers to be able to propel themselves for the most part actively and to maintain a general direction, in spite of changes in wind direction (Schneider, 1962). Numerous species of Lepidoptera engage in long-range migration, with the family Noctuidae being the most predominant migratory group.

One study demonstrated that adults of *Agrotis ipsilon* (Lepidoptera: Noctuidae) were able to travel approximately 1,200 km from their release sites in Louisiana and Texas to Iowa in the span of about three days (Showers *et al.*, 1989). The most well-known example of a migratory moth is the monarch butterfly, *Danaus plexippus* (Lepidoptera: Nymphalidae), specimens of which fly 2,500 km in one year to return to their natal area (Taylor and Reling, 1986, Johnson, 1995).

There are also well-studied examples of annual migration by economically important leafhoppers (Hemiptera: Cicadellidae), *e.g.*, the beet leafhopper, *Circulifer tenellus*, the potato leafhopper, *Empoasca fabae*, and an aster leafhopper, *Macrosteles fascifrons.* These pests use the wind to their advantage to spread passively to areas with better food availability (Taylor and Reling, 1986).

Plant Pathogens

Plant pathogens produce enormous quantities of spores that are passively transported, eventually landing on both target and non-target sites. Spores of different phytopathogenic fungi are carried singly or in clumps by wind and have been trapped far from their release sites.

Ultraviolet (UV) light from the sun causes spore mortality; however, survival during long-distance movement is still possible (Nagarajan and Singh, 1990). Microorganisms have survived the 4,000 km airborne trip from Africa to the Caribbean and the Americas (Griffin *et al.*, 2003).

Sugarcane smut, *Ustilago scitaminea* (Ustilaginales: Ustilaginaceae), is believed to have been carried from Africa to the Caribbean with the North-East trade winds (Purdy *et al.*, 1985, Nagarajan and Singh, 1990); and *Mycosphaerella fijiensis* (Ascomycetes: Mycosphaerellales), the causal agent of black sigatoka disease of banana, is suspected to have spread in the same manner (Nagarajan and Singh, 1990). Hurricane Ivan is suspected to have picked up soybean rust spores in Venezuela and deposited them over Alabama and the panhandle of Florida (FDACS, 2004, Schneider *et al.*, 2005).

Worldwide information on the long-distance dispersal of rust diseases shows that there are certain defined routes that operate during specific months and years, including the route from West Africa to the GCR and Mexico to the northeastern United States (Nagarajan and Singh, 1990).

Conclusions

Most information on pest movement into and within the GCR is anecdotal. Once a pest establishes in a new area, it is difficult to determine the pathway of introduction. Most likely, pests have moved from island to island by natural spread; yet, in most instances, such movement proceeds largely unnoticed. The route of natural movement most likely is that of prevailing winds. In the Caribbean, the prevailing winds would carry insects or plant pathogens from the Windward Islands (the most southeasterly islands), toward the northwest to the Leeward Islands, and on to the Greater Antilles and the southeastern United States. Hurricanes are a potential source for pest movement, but the force of the storm would likely kill or injure most insects that are swept up. Tropical storms with less intense wind strength may be a more likely mechanism for natural movement of plants pests.

The period from June to August is the most probable time for pest movement from countries of the GCR to the United States, as summer is the rainy season in many areas of the Caribbean, with lush plant growth and higher pest densities. While the prevailing winds are favorable for pest movement year-round, in the summer and early fall, tropical storms are more common and could contribute to the spread of plant pests.

Any plant pest is capable of dispersal, usually utilizing a combination of passive and active dispersal means. Lepidopterans, especially noctuid moths, are some of the most successful insects to move into new areas. Airborne plant pathogens such as rusts move very easily across large areas. Arthropods not capable of active flight over long distances, such as mites, scales, aphids, and collembola, can still be blown on the wind. These passive dispersers move at a slower rate than active fliers and their dispersal is completely dependent on the wind direction. Minimal capacity for migration is possessed by tiny gnats and midges, which are behaviorally adapted to fly within a shallow boundary layer at night when atmospheric lift is minimal and which are therefore restricted to travelling the short distances their own powers of flight can sustain (Taylor, 1974).

There is nothing that can be done to prevent the natural spread of pests. Therefore, National Plant Protection Organizations should employ alternative strategies to reduce the risk of pest establishment. Annual surveys are a way to monitor new pest arrivals. Predictive modeling works well for some plant pathogens. The primary focus should be pests that are capable of establishing and causing economic losses or environmental damage.

Recommendations

- ❖ **Conduct annual surveys to monitor the arrival of new pests in an area.**
- ❖ **Use predictive modeling (*e.g.,* degree-day models, *etc.*) for timing of surveys.**
- **Use sterile insect technique (SIT).** Base SIT programs on a target pest list.
- **Develop host-free zones for targeted pests.**

- **Develop biological control methods for targeted pests.**

- **Determine the origin of invasive pests in the GCR.** Because most information about the natural spread of pests is anecdotal, the knowledge of where a pest originated from would be a useful start in understanding natural pest movement. Obviously, it is generally very difficult and often not possible to determine the origin of a pest. Modern technologies, such as trace element or DNA analysis may be useful in some cases.

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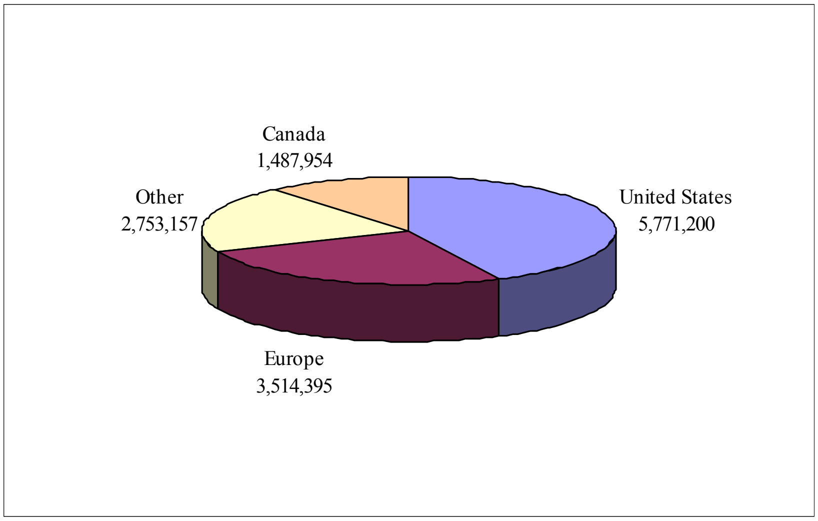
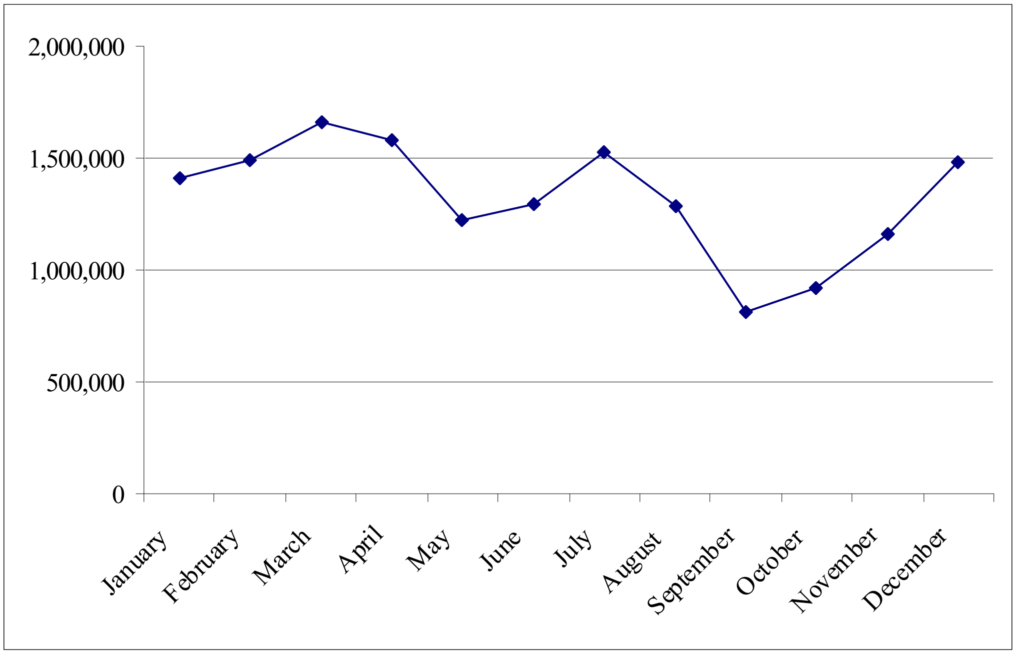
Figures and Tables

Figure 1.1 Origin of tourists to the insular Caribbean in 2006.



Tourist arrival data for 2006 as reported in Table 1.3 (CTO, 2007). Data were not available for the Bahamas, British Virgin Islands, Guadeloupe, Haiti, Martinique, Saint Barts, Saint Kitts and Nevis, and Turks and Caicos Islands. Data were reported as non-resident air arrivals for Antigua and Barbuda, Dominican Republic, and Saint Maarten (Netherlands Antilles). Barbados, Cuba, Dominica, and Grenada reported preliminary data. Saint Eustatius (Netherlands Antilles) and Trinidad and Tobago reported tourist arrivals from January to June only. Data for Puerto Rico and the U.S. Virgin Islands were reported as non-resident hotel registrations. United States arrivals to Cuba were reported in the “Other” category.

Figure 1.2 Tourist arrivals to the Insular Caribbean by month in 2006.



Tourist arrival data for 2006 as reported in Table 1.2 (CTO, 2007). Data were excluded for locations not reporting arrival numbers for all months (Haiti, Saint Eustatius, and Trinidad and Tobago). Data were not available for Guadeloupe, Saint Barts, Saint Kitts and Nevis, Saint Maarten (Netherlands Antilles), and Turks and Caicos Islands. Data were reported as non-resident air arrivals for Antigua and Barbuda, Bahamas, Dominican Republic, and Saint Maarten (Netherlands Antilles). Preliminary data were reported for the British Virgin Islands, Cuba, Dominica, and Martinique. Data for Puerto Rico were reported as non-resident hotel registrations.

Table 1.1 Tourist arrivals by country or territory in 2006.

Region	Country or territory[1]	Number of tourist arrivals	Source[8]
Central America	Belize	247,308	a
	Costa Rica	1,725,261	b
	El Salvador	1,257,952	b
	Guatemala	1,481,547	b
	Honduras	738,667	b
	Nicaragua	773,398	b
	Panama	718,069	b
North America	Florida	3,510,828[2]	c
	Texas	435,474[2]	c
South America	Guyana	113,474	a
	Suriname	159,852[3]	d
West Indies	Anguilla	72,962	a
	Antigua and Barbuda	253,669[4]	a
	Aruba	694,372	a
	Bahamas	1,491,633[4]	a
	Barbados	562,558[5]	a
	British Virgin Islands	356,271[5]	a
	Cayman Islands	267,257	a
	Cuba	2,220,567[5]	a
	Dominica	83,916[5]	a
	Dominican Republic	3,965,055[4]	a
	Grenada	118,490[5]	a
	Haiti	112,267[3]	d
	Jamaica	1,678,905	a
	Martinique	502,053[5]	a
	Montserrat	7,963	a
	Netherlands Antilles	787,106[6]	a, d
	Puerto Rico	1,485,296[7]	a
	Saint Lucia	302,510	a
	Saint Vincent and the Grenadines	97,432	a
	Trinidad and Tobago	460,195[3]	d
	U.S. Virgin Islands	671,362	a

[1]Tourist arrival data were not available for Guadeloupe, Saint Barts, Saint Kitts and Nevis, Turks and Caicos Islands, and the United States (Alabama, Louisiana, and Mississippi).
[2]Overseas (excludes Canada and Mexico) non-resident air arrivals to airports in Florida (Miami, Orlando, and Sanford) and Texas (Houston).
[3]Tourist arrival data were not available for all of 2006; data reported represents 2005 stop-over arrivals (CTO, 2008).
[4]Arrivals reported as non-resident air arrivals.
[5]Preliminary data.
[6]Netherlands Antilles includes the islands of Curaçao, Bonaire, Saint Maarten, Saint Eustatius, and Saba. Arrivals reported for Saint Maarten were non-resident air arrivals. Arrivals to Saint Eustatius for 2006 were reported only for the time period of January to June so data from 2005 were substituted (10,355 tourist stop-over arrivals reported for Saint Eustatius in 2005 (CTO, 2008)).
[7]Arrivals reported as non-resident hotel registrations.
[8]Data for this table were obtained from the following sources: a (CTO, 2007); b (SICA, 2008); c (OTTI, 2007a); and d (CTO, 2008).

Table 1.2 Excursionist[6] arrivals by region and country or territory in 2006.

Region	Country or territory[1]	Number of excursionist arrivals	Source[5]
Central America	Belize	655,931	a
	Costa Rica	345,646	b
	El Salvador	222,434	b
	Guatemala	20,522	b
	Honduras	397,689	b
	Nicaragua	125,301	b
	Panama	459,093	b
West Indies	Antigua and Barbuda	471,623	a
	Aruba	591,474	a
	Bahamas	3,076,397	a
	Barbados	539,092[2]	a
	British Virgin Islands	443,987[2]	a
	Cayman Islands	1,930,136	a
	Dominica	379,503[2]	a
	Dominican Republic	303,489	a
	Grenada	218,838[2]	a
	Haiti	368,018[3]	c
	Jamaica	1,315,333	a
	Martinique	95,812[2]	a
	Montserrat	285[3]	c
	Netherlands Antilles	1,821,606[4]	a
	Puerto Rico	1,315,079[3]	c
	Saint Lucia	359,593	a
	Saint Vincent and the Grenadines	106,474	a
	Trinidad and Tobago	67,193[3]	c
	U.S. Virgin Islands	1,901,275	a

[1]Excursionist arrival data were not available for Anguilla, Cuba, Guadeloupe, Saint Barts, Saint Kitts and Nevis, Turks and Caicos Islands, Guyana, Suriname, and the United States (Alabama, Florida, Louisiana, Mississippi, and Texas).
[2]Preliminary data.
[3]Excursionist arrival data were not available for all of 2006; data reported represents 2005 excursionist arrivals (reported as cruise passenger arrivals) (CTO, 2008).
[4]Netherlands Antilles includes the islands of Curaçao, Bonaire, Saint Maarten, Saint Eustatius, and Saba. Excursionist arrival data were not available for Saint Eustatius and Saba.
[5]Data for this table were obtained from the following sources: a – reported as number of cruise passengers. (CTO, 2007); b – reported as number of excursionists (SICA, 2008); and c – reported as number of cruise passengers. (CTO, 2008).
[6] Visitor staying for less than 24 hours and not staying overnight.

Table 1.3 Pest interceptions on maritime (primarily cruise ship[18]) baggage at U.S. ports of entry located in the U.S. Gulf States (Florida, Alabama, Louisiana, Mississippi, and Texas) during 2007. The number of specimens intercepted is listed after the pest name. Note: These interceptions were the result of a special data collection effort targeting *Raoiella indica* (USDA, 2008d).

Port of entry	Origin	Inspected host	Pest	Pest type
FL Miami	St. Maarten	*Cocos nucifera* (leaf)	*Aonidiella orientalis* (Diaspididae): 1	Insect
FL Miami	Mexico	*Cocos nucifera* (leaf)	*Hoplandrothrips flavipes* (Phlaeothripidae): 1	Insect
FL Miami	Jamaica	*Cocos nucifera* (leaf)	Oribatida species: 2	Mite
FL Miami	Jamaica	*Cocos nucifera* (leaf)	Macrochelidae species: 1	Mite
FL Miami	Jamaica	*Cocos nucifera* (leaf)	Ameroseiidae species: 2	Mite
FL Miami	Jamaica	*Cocos nucifera* (leaf)	Tyrophagus species (Acaridae): 1	Mite
FL Miami	Jamaica	*Cocos nucifera* (leaf)	*Hoplandrothrips flavipes* (Phlaeothripidae): 13	Insect
FL Miami	Jamaica	*Cocos nucifera* (leaf)	Tyrophagus species (Acaridae): 1	Mite
FL Miami	Jamaica	*Cocos nucifera* (leaf)	Parasitidae species: 2	Mite
FL Miami	Mexico	*Cocos nucifera* (leaf)	Hemiberlesia lataniae (Diaspididae): 1	Insect
FL Miami	Unknown	*Cocos nucifera* (leaf)	*Aonidiella orientalis* (Diaspididae): 2	Mite
FL Miami	Unknown	Baggage	*Sorghum* sp. (Poaceae)	Weed
FL Miami	Haiti	*Cocos nucifera* (leaf)	Mesostigmata species: 10	Mite
FL Miami	Unknown	At Large	*Gryllus* sp. (Gryllidae): 1	Insect
FL Miami	Mexico	*Cocos nucifera* (leaf)	Aleyrodicinae species (Aleyrodidae): 5	Insect
FL Miami	St. Maarten	*Cocos nucifera* (leaf)	*Raoiella indica* (Tenuipalpidae): 2	Mite
FL Miami	St. Maarten	Handicrafts	*Raoiella indica* (Tenuipalpidae): 1	Mite
FL Miami	Puerto Rico	*Cocos nucifera* (leaf)	Tenuipalpidae species: 6	Mite
FL Miami	Puerto Rico	*Cocos nucifera* (leaf)	*Oligonychus* sp. (Tetranychidae):1	Mite
FL Miami	St. Maarten	*Cocos nucifera* (leaf)	*Raoiella indica* (Tenuipalpidae): 9	Mite
FL Miami	Mexico	*Cocos nucifera* (leaf)	Aleurodicinae species (Aleyrodidae): 3	Insect
FL Port Everglades	D.R.	Palmaceae sp.	*Raoiella indica* (Tenuipalpidae): 1	Mite
FL Miami	St. Maarten	*Cocos nucifera* (leaf)	*Raoiella indica* (Tenuipalpidae): 2	Mite
FL Miami	Unknown	*Cocos nucifera* (leaf)	*Raoiella indica* (Tenuipalpidae): 24	Mite
FL Miami	Unknown	*Cocos nucifera* (leaf)	*Tetranychus* sp. (Tetranychidae): 3	Mite
FL Miami	St. Maarten	*Cocos nucifera* (leaf)	*Tetranychus* sp. (Tetranychidae): 1	Mite
FL Miami	Unknown	*Cocos nucifera* (leaf)	*Aleurotrachelus atratus* (Aleyrodidae)	Insect
FL Miami	D.R.	Handicrafts	*Resseliella* sp. (Cecidomyiidae): 37	Insect
TX Houston	Brazil	*Citrus* sp.	*Guinardia citricarpa* (Botryosphaeriaceae)	Disease
FL Miami	St. Maarten	*Cocos nucifera* (leaf)	*Raoiella indica* (Tenuipalpidae): 61	Mite

[18]The data source (USDA, 2008b) does not specify vessel type; however, in many cases a ship name is listed, providing some indication of the identity of the vessel.

Table 1.4 Number of people moving across four major border crossings of the Mexico-Guatemala border, June-December 2004 (Solís, 2005).

Border crossings	From Mexico into Guatemala		From Guatemala into Mexico	
	Guatemalans	**Non-Guatemalans**	**Guatemalans**	**Non-Guatemalans**
El Carmen	7,418	18,448	41,601	9,894
Tecún-Umán	13,181	12,100	17,335	9,053
La Mesilla	2,074	15,175	14,184	5,243
Gracias a Dios	248	1,887	6,083	1,713
Total	**22,921**	**47,610**	**79,203**	**25,903**

Table 1.5 Influx of temporary farm workers from Guatemala into Chiapas, Mexico (Solís, 2005).

Year	Number of workers
1997	60,783
1998	49,655
1999	64,691
2000	69,036
2001	42,471
2002	39,321
2003	46,318

Figure 2.1 95% binomial confidence intervals for plant QM approach rates in international airline passenger baggage at U.S. ports of entry between January 1, 2005 and August 22, 2007. By travel reason (sample sizes in parenthesis). Data source: (USDA, 2008f).

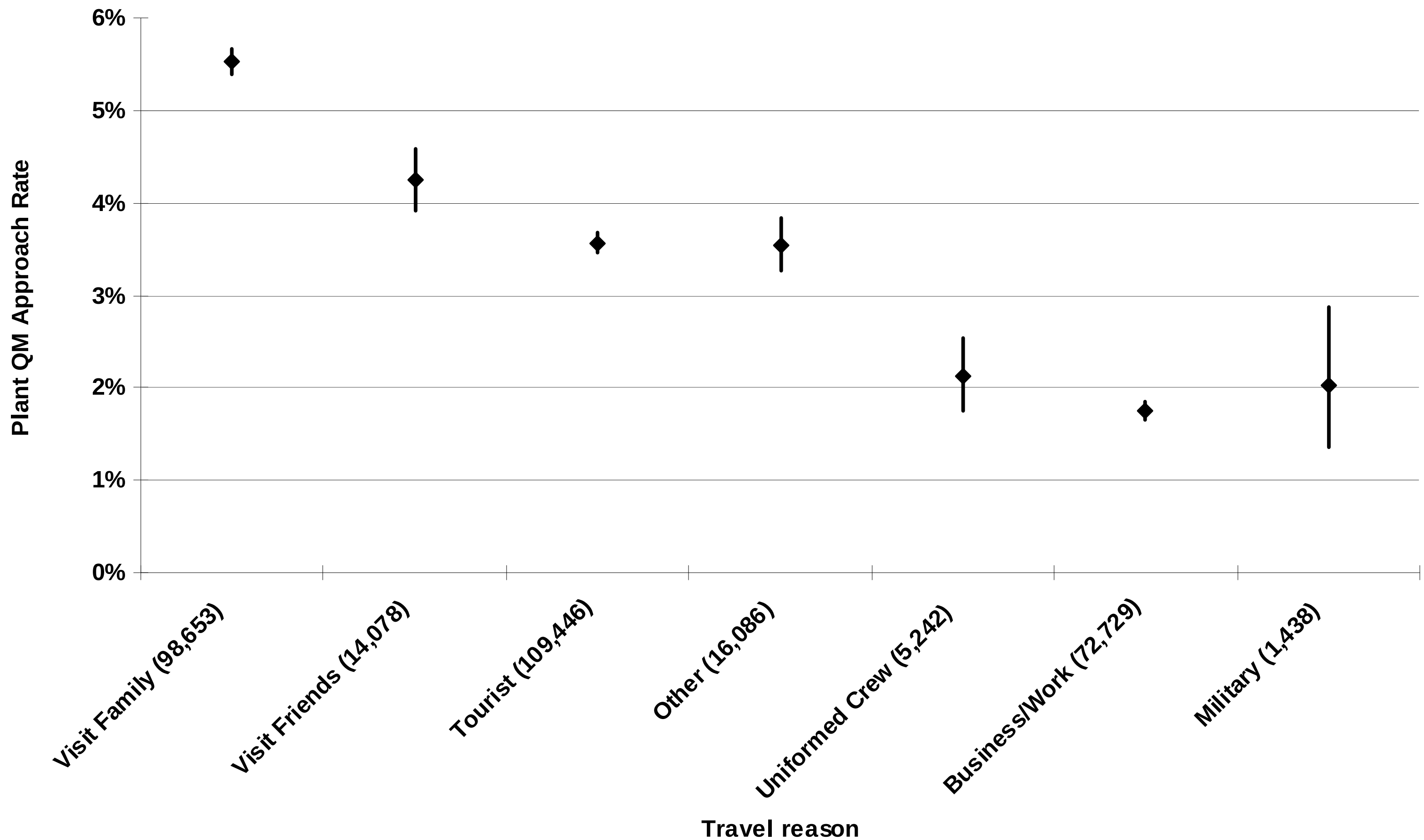


Figure 2.2 95% binomial confidence intervals for plant QM approach rates in international airline passenger baggage at U.S. ports of entry between January 1, 2005 and August 22, 2007. By country of passenger origin (sample sizes in parenthesis). Shows the 25 countries of origin with the highest approach rates. Countries with samples sizes < 30 are omitted. Data source: (USDA, 2008f).

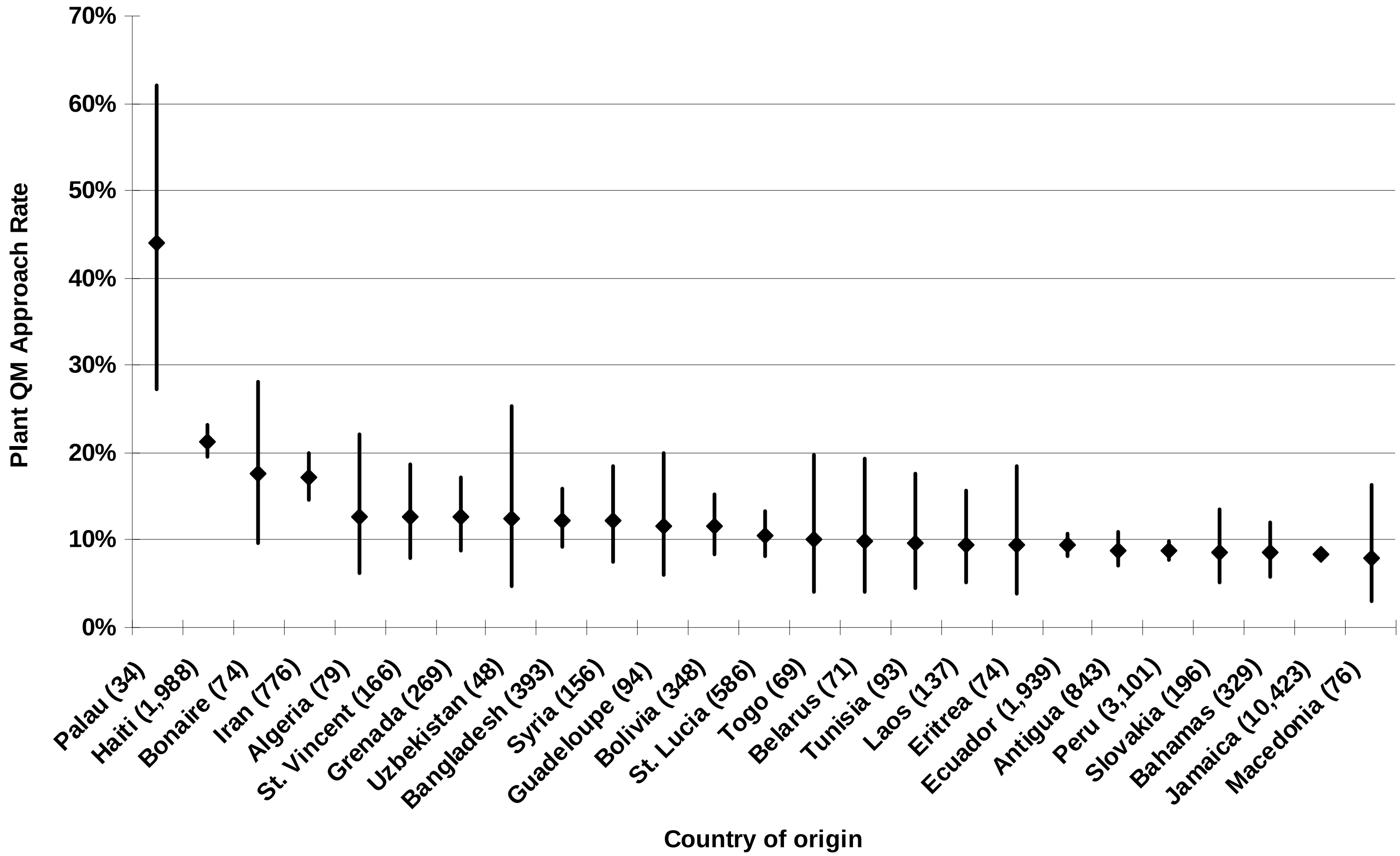


Figure 2.3 95% binomial confidence intervals for plant QM approach rates in international airline passenger baggage at U.S. ports of entry between January 1, 2005 and August 22, 2007. Caribbean countries of passenger origin (sample sizes in parenthesis). Countries with samples sizes < 30 are omitted. Data source: (USDA, 2008f).

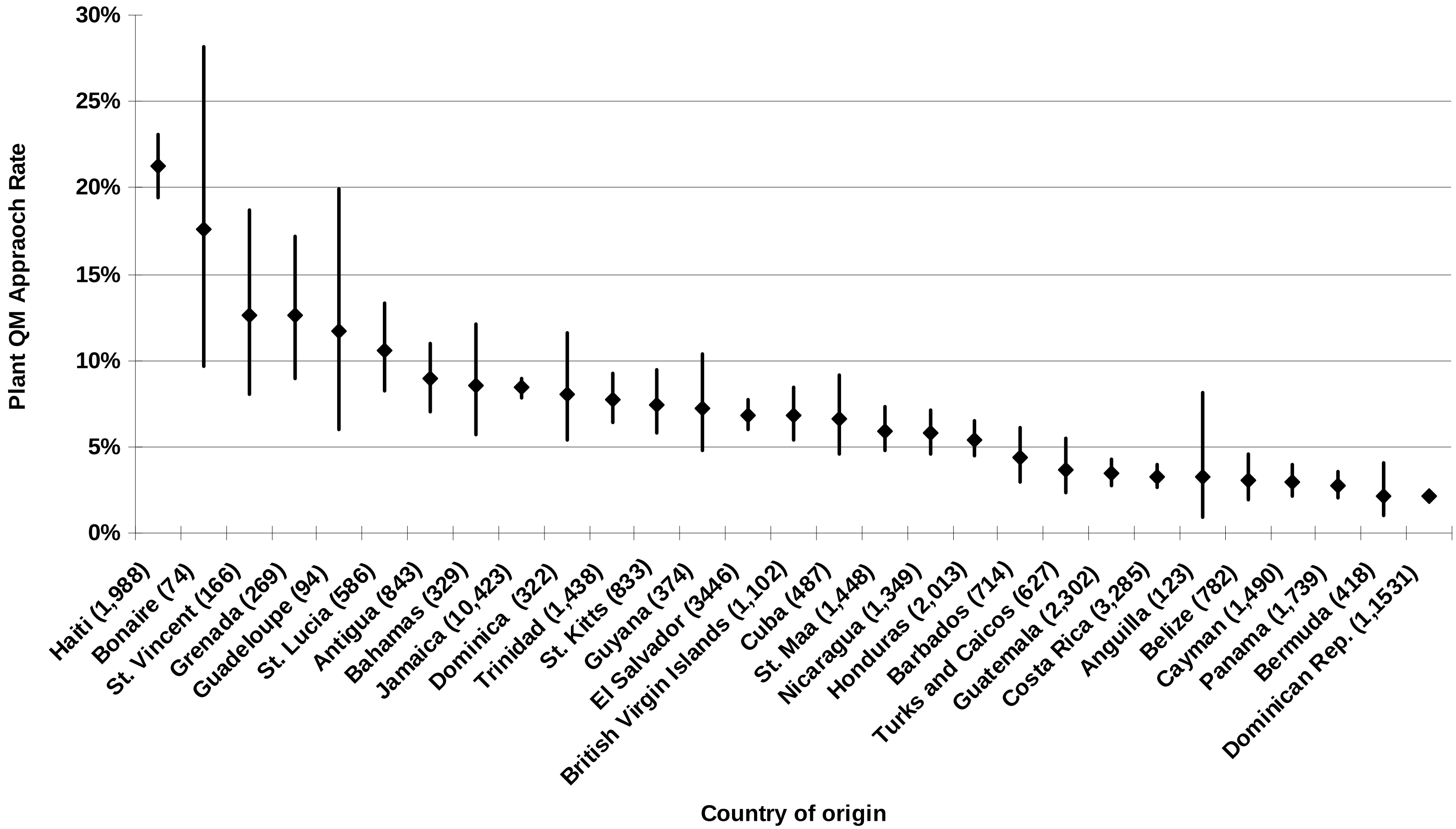


Figure 2.4 Estimated annual number of plant QMs arriving at U.S. airports (95% binomial confidence intervals). By country of origin (sample sizes in parenthesis). The 25 countries with the highest predicted number of plant QMs are depicted.

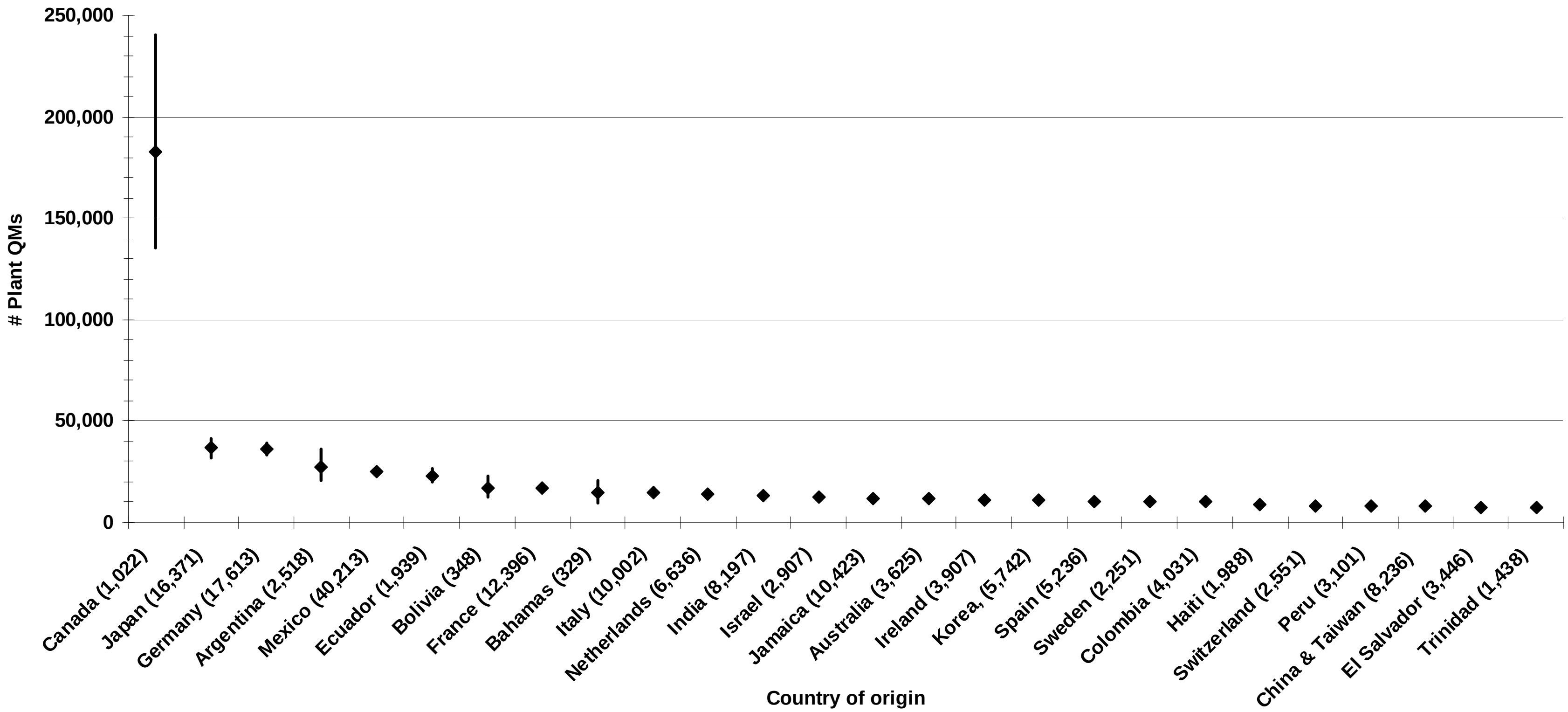


Figure 2.5 Same as figure 2.4, but Canada not displayed to show data for the other countries at a smaller scale.

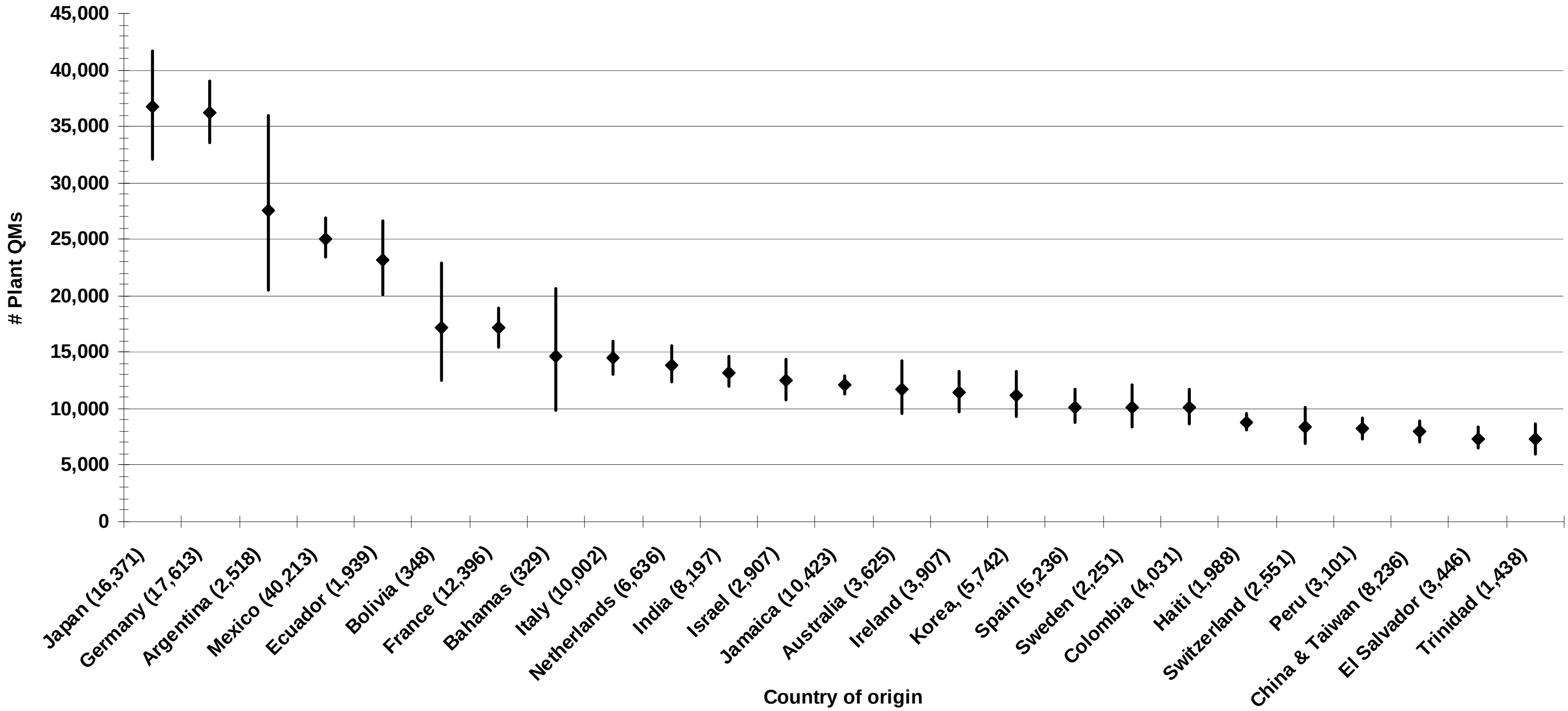


Figure 2.6 95% binomial confidence intervals for plant QM approach rates in international airline passenger baggage at U.S. ports of entry between January 1, 2005 and August 22, 2007. Tourists only. By country of origin. Data source: (USDA, 2008f).

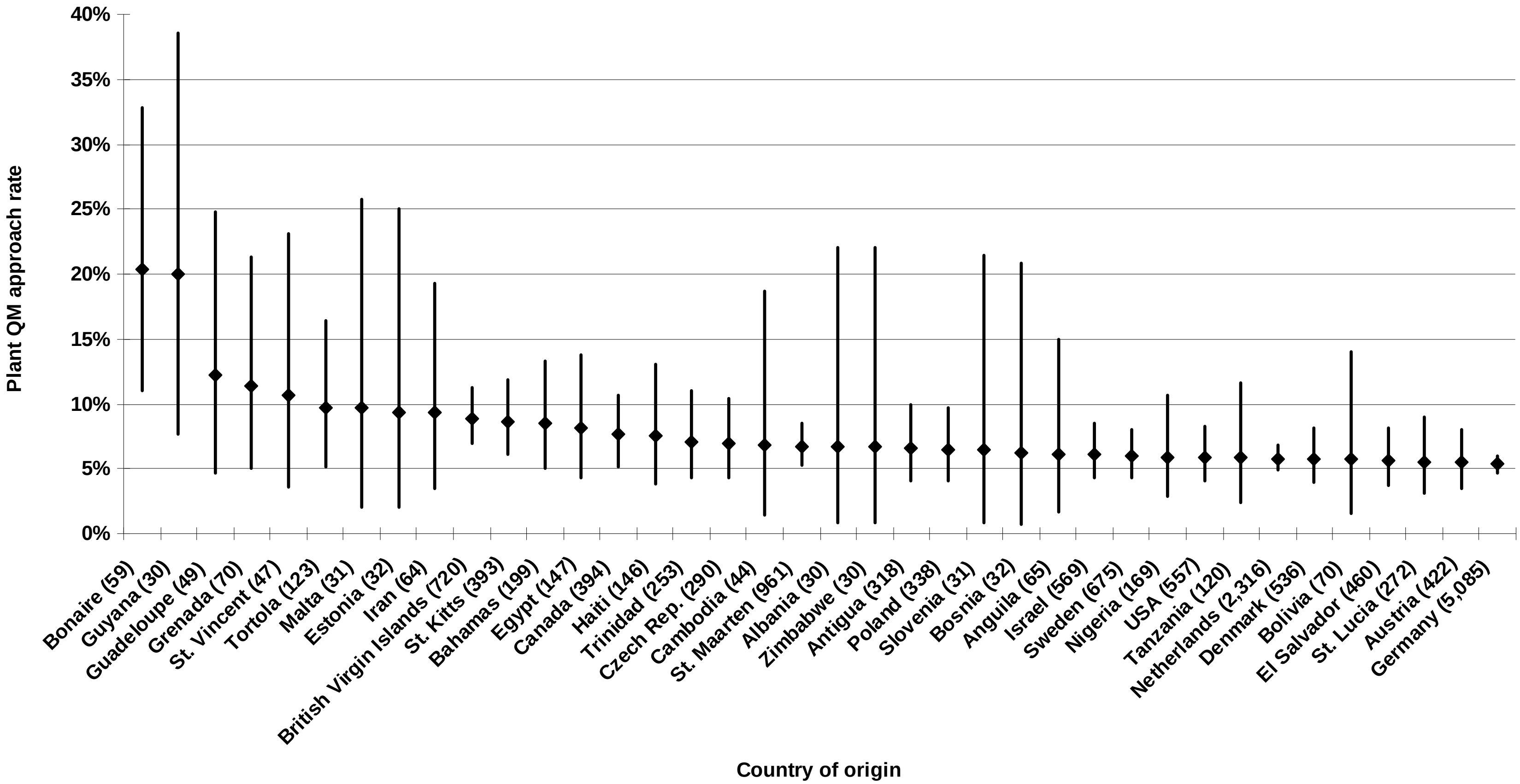


Figure 2.6 (continued) 95% binomial confidence intervals for plant QM approach rates in international airline passenger baggage at U.S. ports of entry between January 1, 2005 and August 22, 2007. Tourists only. By country of origin. Data source: (USDA, 2008f).

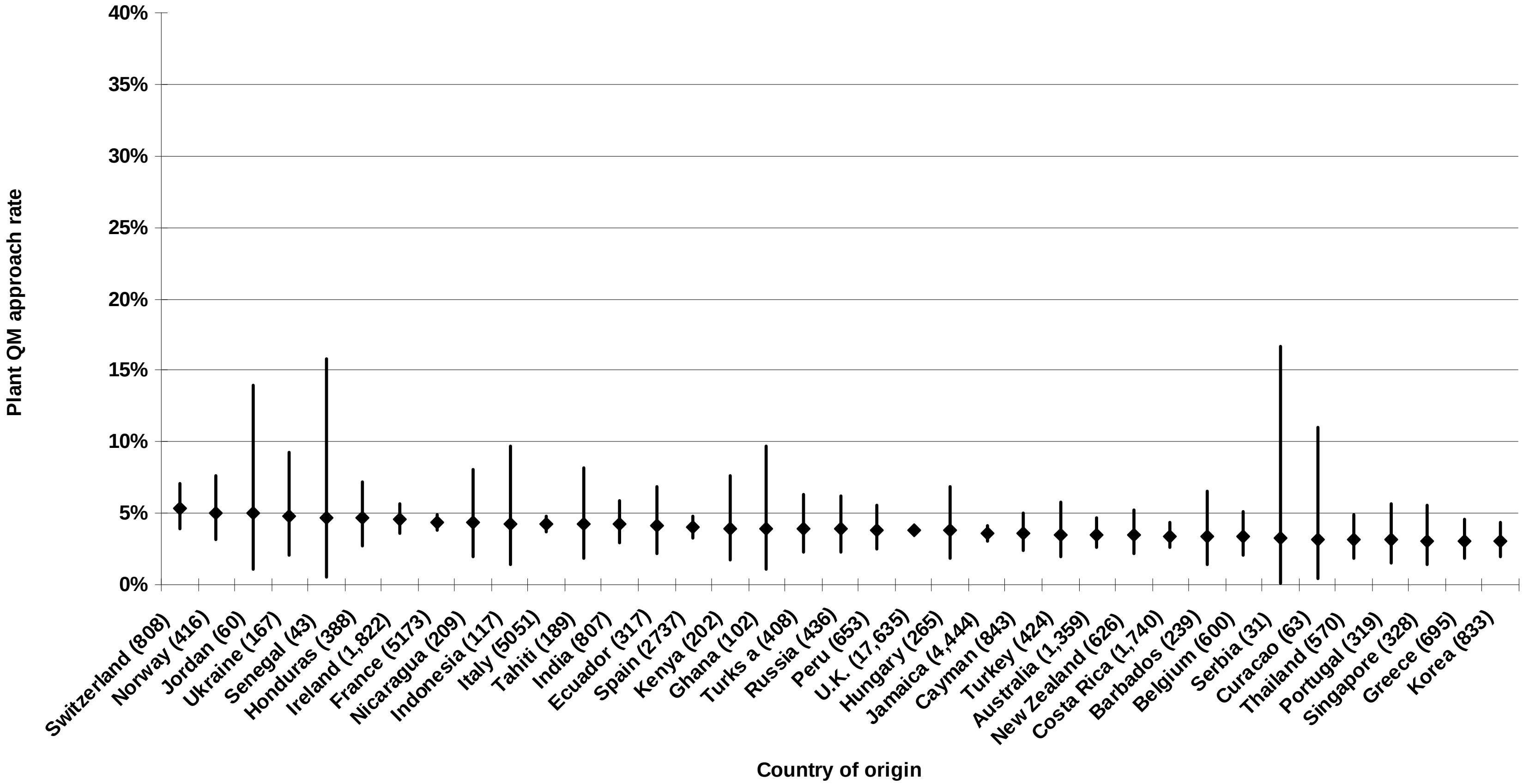


Table 2.1 Results of Agricultural Quarantine Inspection Monitoring (AQIM) of international air passengers arriving at U.S. airports during fiscal years 2005 and 2006. The sampling unit is the group of passengers traveling together under one U.S. Customs declaration. The table shows the number of passenger groups that were found to have quarantine materials (QMs), the number of passenger groups inspected, the estimated proportion of passenger groups that carry QMs ("approach rate"), and the lower and upper 95% binomial confidence limits for this estimate. It also lists the total annual number of passengers entering the United States, the average number of passengers per group, and the annual number of groups entering the United States. Finally, it shows the lower and upper confidence limits for the estimated total annual number of QMs entering the United States.

Pax with QMS[19]	Pax inspected[20]	Approach rate[21]	Lower 95% CL[22]	Upper 95% CL[23]	Pax entering[24]	Group size[25]	Pax groups entering[26]	QMs entering (Lower 95% CL)[27]	QMs entering (Upper 95% CL)[28]
11,977	319,599	3.75%	3.70%	3.81%	52 million	1.4	37 million	1.64 million	1.68 million

19 Number of passenger groups where quarantine materials were found (Data source: USDA Agricultural Quarantine Monitoring for FY 2005 and 2006)
20 Number of passenger groups inspected (Data source: USDA Agricultural Quarantine Monitoring for FY 2005 and 2006)
21 Percentage of passenger groups inspected where QMIs were found
22 Lower 95% confidence limit of the approach rate
23 Upper 95% confidence limit of the approach rate
24 Number of passengers entering the United States annually (OTTI, 2007a)
25 Average number of passengers per group (Data source: USDA Agricultural Quarantine Monitoring for FY 2005 and 2006)
26 Number of passenger groups entering the United States annually (number passengers divided by average group size)
27 Lower 95% confidence limit of the approach rate x Pax groups entering x average number of QMs per declaration (1.2)
28 Upper 95% confidence limit of the approach rate x Pax groups entering x average number of QMs per declaration (1.2)

Table 2.2 Number and percentage of travelers in the various travel reason categories. Data source: Agricultural Quarantine Inspection Monitoring, fiscal years 2005 and 2006 (USDA, 2008f).

Travel Reason	Frequency	Percent
Tourist	109,446	34
Family Visit	98,653	31
Business/Work	72,729	23
Visit Friends	14,078	4
Uniformed Crew	5,242	1
Military	1,438	0.5
Other	16,086	6

Table 2.3 Annual number of visitors arriving in Caribbean countries by airplane and percentage of visitors that are tourists. Periods indicate that no data were available. Data source: (UNWTO, 2006).

Country	Visitors by air	Tourists
Anguilla	24,000	83%
Antigua	245,000	.
Aruba	728,000	92%
Bahamas	1,450,000	82%
Barbados	546,000	81%
Belize	163,000	93%
Bonaire	63	78%
British Virgin Islands	220,000	95%
Cayman Islands	260,000	.
Costa Rica	1,088,000	72%
Cuba	2,017,000	91%
Curacao	233,000	86%
Dominica	.	.
Dominican Republic	3,450,000	95%
Grenada	128,000	51%
Guatemala	434,000	.
Guyana	122,000	.
Haiti	96,000	.
Honduras	272,000	.
Jamaica	1,415,000	80%
Martinique	404,000	81%
Montserrat	9,600	.
Nicaragua	204,000	.
Panama	476,000	.
Puerto Rico	3,541,000	.
Saba	7,300	.
St. Eustatius	.	.
St. Kitts and Nevis	122,000	.
St. Lucia	.	89%
St. Maarten	475,000	.
St. Vincent and the Grenadines	100,000	62%
Trinidad	443,000	67%
Turks and Caicos	158,000	57%
U.S. Virgin Islands	655,000	.

Table 3.1 Plant materials/plant pests intercepted in public and private mail of worldwide origin during AQIM monitoring at 11 U.S. ports of entry, 2005-2007 (USDA, 2008f).

Type of plant material	**Public mail** (Sample size: 76,132)	**Private mail** (Sample size: 18,455)
Fresh fruits	apples, avocado, bananas, berries (unspecified), breadfruit, cannonball fruit, citrus, cucurbits, dates, eggplants, figs, guavas, hog plum (mombin), jackfruit, jujube, longan, mango, naranjilla, olives, passion fruit, peaches, peach palm, pears, chili and bell peppers, persimmons, physalis, plums, pumpkins, quince, rambutan, squash, tomato, and tuna (prickly pear fruit)	ackee, apple, avocado, banana, berries, blueberries, chayote, cherries, citrus, cucumber, grapes, kiwi, mango, olives, papayas, peaches, pears, peppers, physalis, pineapple, plantain, plum, squash, strawberries, tomato, tuna (cactus fruit), ya pears, and other unspecified fruit
Dried, processed, or preserved fruits	general dried or preserved fruit (unspecified), dried mango, and dried chili peppers	dried chilis, raisins, dry mango, and other dried or frozen fruit.
Propagative plant materials, excluding seeds	bamboo, cactus plants or pads, cassava, dasheen, entire plants (candytuft, conifers, unidentified plants, aquatic plants), flower bulbs, garlic, ginger root, ginseng root, lemongrass, onions, orchids, plumeria, potatoes, sugarcane, sweet potatoes, yams, and other unidentified roots or tubers	aloe, bamboo, boxwood, bulbs (unspecified flowers), cassava, dasheen, garlic, geranium, lemongrass, orchids, sugarcane and other unspecified plants
Fresh plant material not likely to be propagative (leaves, fresh herbs, *etc.*)	aloe leaves, unidentified branches with leaves, citrus leaves, curry leaves, cut flowers, epazote, eryngium, ferns, unspecified fresh herbs, unspecified greenery, unspecified leaves, mugwort (Artemisia), palm shoots or foliage, tea bush, and thyme	citrus leaves, cut flowers, eucalyptus, euphorbia, foliage, and palm leaves
Herbs, spices, and flowers, typically dried or processed	bay leaves, curry, cinnamon, citrus peel, dried flowers, medicinal herbs, pepper, unspecified spices and dried herbs	spices

Type of plant material	**Public mail** (Sample size: 76,132)	**Private mail** (Sample size: 18,455)
Fresh vegetables	beans and bean sprouts, beets, corn, okra, peas, and other unspecified vegetables	artichokes, beans, broccoli, carrots, celery, corn, loroco, and other unspecified vegetables
Seeds and pods	dried beans, cacao bean pods, coconuts, cucurbit seeds, flower seeds, melon seeds, palm seeds, pine seeds, pumpkin seeds, sesame, soybeans, large amounts of unspecified seed, and tamarind	coconut, pumpkin seeds, soybeans, and other unspecified seeds
Nuts (which may also be propagative)	almonds, betel nuts, cashews, chestnuts, peanuts, pistachios, walnuts and unspecified nuts	almonds, cashews, macadamia nuts, and peanuts
Grains and grain products	processed items like wheat or flour products, rice, red rice unspecified whole grain	flour products, grain, quinoa, and rice
Other	honey and honey combs; hay and straw, including rice straw; mushrooms, processed vegetables, seaweed (unclear if fresh or dried), and soil and sand	cotton, honey, insects, jute, and one snail, clay, soil

Table 3.2 Relative frequency of types of plant materials/plant pests intercepted in public and private mail of worldwide origin during AQIM monitoring at 11 U.S. ports of entry, 2005-2007 (USDA, 2008f).

	Origin: Worldwide		**Origin: GCR (Except United States)**		
Item	**Public mail** Sample size: 2,042	**Private mail** Sample size: 1,042	**Public mail** Sample size: 77	**Private mail** Sample size: 386	**Relative Risk**
Seeds/Pods	20%	24%	12%	5%	High: seedborne and seed transmitted pests, weed seeds, all intended for planting
Herbs, spices, and flowers, dried or processed	16%	3%	8%	4%	Variable: depends on method and level of processing. Processed items for consumption likely low risk.
Fruits, fresh	11%	7%	16%	5%	Medium: many associated pests likely to remain viable, but use for consumption is lower risk than items for planting.
Fruits, dried, preserved, processed	10%	4%	16%	3%	Variable: depends on method and level of processing.
Propagative plant materials (includes plants, roots, shoots, and tubers)	9%	3%	6%	4%	High: live plant materials maintain viable pests, weed seed contaminants, pest plants, and all intended for planting.
Fresh plant material (leaves, fresh herbs, branches with leaves)	8%	7%	9%	2%	Medium: many associated pests likely to remain viable, but use for consumption is lower risk than items for planting.
Coffee/Tea	6%	13%	9%	30%	Low: although somewhat variable depending on method and level of processing.
Grains/Grain products	3%	2%	9%	0%	Medium to low: although associated pests likely to remain viable, use for consumption is lower risk than items for planting, low risk items are processed grain products.

	Origin: Worldwide		Origin: GCR (Except United States)		
Item	**Public mail** Sample size: 2,042	**Private mail** Sample size: 1,042	**Public mail** Sample size: 77	**Private mail** Sample size: 386	**Relative Risk**
Miscellaneous	3%	1%	1%	1%	Variable: depending on items, processing, and intended use.
Mushrooms	3%	0%	0%	0%	Variable: depends on fresh or dried condition, method and level of processing and other associated pests or soil.
Nuts	3%	3%	1%	6%	Variable: depends on method and level of processing, whole untreated in the shell is higher risk (can be propagative) than fumigated, irradiated, or shelled and roasted nuts.
Vegetables, fresh	3%	4%	8%	3%	Medium: many associated pests likely to remain viable, but use for consumption is lower risk than items for planting.
Wood/Wood items	2%	20%	4%	23%	Medium: many associated pests likely to remain viable, but use for consumption is lower risk than items for planting.
Vegetables, dried or preserved	2%	1%	0%	0%	Variable: depends on method and level of processing.
Soil	1%	7%	1%	9%	High: may contain seeds, soilborne arthropods and pathogens or other pests.
Straw/Hay	1%	0%	0%	0%	Medium: many associated pests likely to remain viable, but use for consumption is lower risk than items for planting, contaminating weed seeds viable after consumption by animals.

	Origin: Worldwide		Origin: GCR (Except United States)		
Item	**Public mail** Sample size: 2,042	**Private mail** Sample size: 1,042	**Public mail** Sample size: 77	**Private mail** Sample size: 386	**Relative Risk**
Honey/Honey combs	0%	2%	0%	1%	Medium: bee larvae, bee pests, or pathogens may be present if unprocessed.
Insects	0%	1%	0%	3%	Variable: depends on viability and species.

Table 3.3 Inspection results for international public and private mail parcels arriving in the United States (2005-2007). Data source: (USDA, 2008f).

		Number of packages with		Approach rate (95% binomial C.I.) for packages with	
	Packages inspected	**Plant materials or pests**	**Plant materials/Plant pests of U.S. quarantine significance**	**Plant materials/Plant pests**	**Plant materials/Plant pests of U.S. quarantine significance**
Total Private (Express) Mail	18,455	1,042	24	5.6% (5.3-6.0 %)	0.13% (0.08-0.19 %)
Caribbean Private (Express) Mail	374	.	6	.	1.6% (0.6-3.6%)
Total Public Mail (Parcel Post)	76,132	2,042	855	2.7% (2.6-2.8 %)	1.15% (1.1-1.2 %)
Caribbean Public Mail (Parcel Post)	2,414	77	18	3.2% (2.5-4.0%)	0.8% (0.4-1.2%)

Table 3.4 Total average number of international public mail packages received by UPU member states in the GCR between 2003 and 2005 (Universal Postal Union, 2008) and estimated number of packages arriving with plant materials/plant pests. (Calculated as number of packages arriving multiplied by approach rate: 95% confidence limit 2.6-2.8%)

Postal Administrations in UPU	Total international parcels received	Estimated number of parcels arriving with plant materials/plant pests		Year of data
		Lower 95% confidence limit	Upper 95% confidence limit	
Anguilla	1,895	49	53	2003
Antigua and Barbuda	14,042	365	393	2005
Aruba	7,067	184	198	2003
Bahamas	35,641	927	998	2005
Barbados	46,717	1,215	1,308	2005
Belize	33,447	870	937	2006
Cayman Islands	29,481	766	825	2005
Costa Rica	29,889	777	837	2006
Cuba	4,748	123	133	2001
Dominica	8,361	217	234	2005
Dominican Republic	15,469	402	433	2006
El Salvador	29,853	776	836	2006
Grenada	8,193	213	229	2006
Guadeloupe	no data			
Guatemala	21,397	556	599	2006
Guyana	12,058	313	338	2005
Haiti	3,978	103	111	2004
Honduras (Rep.)	no data			
Jamaica	83,432	2,169	2,336	2005
Martinique	no data			
Montserrat	1,567	41	44	2005
Netherland Antilles	29,328	762	821	2006
Nicaragua	4,978	129	139	2002
Panama (Rep.)	28,056	729	786	2006
Saint-Barthélemy	no data			
Saint Christopher (St. Kitts) and Nevis	11,480	298	321	2005
Saint Lucia	12,299	320	344	2006
St. Martin	no data			
Saint Vincent and the Grenadines	no data			
Suriname	4,150	107	116	2006
Trinidad and Tobago	48,900	1,271	1,369	2005
Turks and Caicos Islands	1,000	26	28	2004
Virgin Islands	6,254	163	175	2006
GCR Total (excluding U.S.)	**533,680**	**13,876**	**14,943**	

Table 3.5 Pests (insects) intercepted from private mail packages between October 1, 2007 and September 30, 2008 in Miami, Florida (USDA, 2008d).

World region of origin	**Country of origin**	**Inspected Host**	**Pest**	**Reportable in U.S.?**
GCR	El Salvador	*Fernaldia pandurata* (cut flower)	Aphididae, species of	yes
GCR	El Salvador	*Fernaldia pandurata* (cut flower)	*Aphis gossypii* (Aphididae)	no
GCR	Guatemala	*Rubus* sp. (fruit)	Species of Anthocoridae and Cucijidae	no
GCR	Nicaragua	Unknown plant parts	Cecidomyiidae, species of	yes
GCR	Nicaragua	Unknown plant parts	Species of Chilopoda and Coleoptera	no
Europe	Netherlands	*Achillea* sp. (cut flower)	Plusiinae, species of (Noctuidae)	yes
Europe	Netherlands	*Astilbe* sp. (cut flower)	Miridae, species of	yes
North America	Mexico	Mail	*Phyciodes claudina* (Nymphalidae)	no
South America	Colombia	*Chrysanthemum* sp. (cut flower)	*Frankliniella* sp. (Thripidae)	yes
South America	Ecuador	*Delphinium* sp. (cut flower)	*Frankliniella auripes* (Thripidae)	yes
South America	Peru	*Lactuca* sp. (leaf)	*Nysius* sp. (Lygaeidae)	yes
South America	Peru	*Lactuca* sp. (leaf)	Reduviidae, species of	no

Table 3.6 Pests (insects) intercepted from public (USPS) mail packages between October 1, 2007 and September 30, 2008 in Miami, Florida (USDA, 2008d).

World region of origin	Country of origin	Inspected host	Pest	Reportable into U.S.?
GCR	Belize	Dried plant material (leaf)	Pyralidae, species of	yes
GCR	Dominican Republic	Mail	Tephritidae, species of	yes
GCR	Guatemala	*Phaseolus vulgaris* (fruit)	*Acanthoscelides obtectus* (Bruchidae); Otitidae, species of	no
GCR	Guatemala	Unknown plant parts (stem)	Species of Agromyzidae, Aleyrodidae, Noctuidae	yes
GCR	Guatemala	*Zea mays* (fruit)	Species of Cleridae, Syrphidae	no
GCR	Guatemala	*Hordeum vulgare* (seed)	Coleoptera, species of; *Sitophilus* sp. (Dryophthoridae)	no
Europe	Spain	*Zea mays* (seed)	*Sitophilus* sp. (Dryophthoridae)	no
North America	Mexico	*Phaseolus* sp. (fruit and seed)	*Acanthoscelides obtectus* (Bruchidae)	yes
North America	Mexico	*Mangifera indica* (fruit and seed)	*Anastrepha* sp. (Tephritidae)	yes
North America	Mexico	*Prunus persica* (fruit)	*Anastrepha* sp. (Tephritidae)	yes
North America	Mexico	Wood (wood product)	Species of Anobiidae, Coleoptera	no
North America	Mexico	*Araucaria* sp. (seed)	*Cydia araucariae* (Tortricidae)	yes
North America	Mexico	Stored products	*Dermestes* sp. (Dermestidae)	no
North America	Mexico	*Polypodium* sp. (plant)	*Galgupha guttiger* (Cydnidae)	no
North America	Mexico	*Prunus* sp. (fruit)	Pyralidae, species of	yes
South America	Bolivia	*Pouteria* sp. (fruit)	Curculionidae, species of	yes
South America	Brazil	*Phaseolus vulgaris* (seed)	*Acanthoscelides obvelatus* (Bruchidae)	yes
South America	Brazil	Araucaria araucana (seed)	Coleoptera, species of	no
South America	Brazil	*Araucaria araucana*, *Araucaria* sp. (seed)	*Cydia araucariae* (Tortricidae), Lepidoptera, species of	yes
South America	Brazil	*Phaseolus vulgaris* (seed)	Diptera, species of	no
South America	Colombia	*Limonium* sp. (cut flower)	*Dinoderus* sp. (Bostrichidae)	no

Table 3.7 Categories of prohibited items seized in public and private mail entering the United States (2000-2005) at the international mail facility, San Francisco, CA; 199 items in 189 packages (USDA-APHIS-SITC, 2005).

Plant-Related Item	Quarantine Items Seized
Seeds	67
Fresh fruit	56
Propagative	32
Leaves	12
Grain	8
Minimally processed fruit	7
Fresh vegetables	4
Soil	4
Nuts	3
Insect	2
Straw	2
Honeycomb	1
Miscellaneous (moss)	1

Figure 4.1 Container traffic through the Greater Caribbean Region; numbers above depicted route represent numbers of TEUs in thousands for 1999 and (in parenthesis) for 2002; TEU = equivalent of a 20-foot cargo container (adapted from Frankel, 2002).

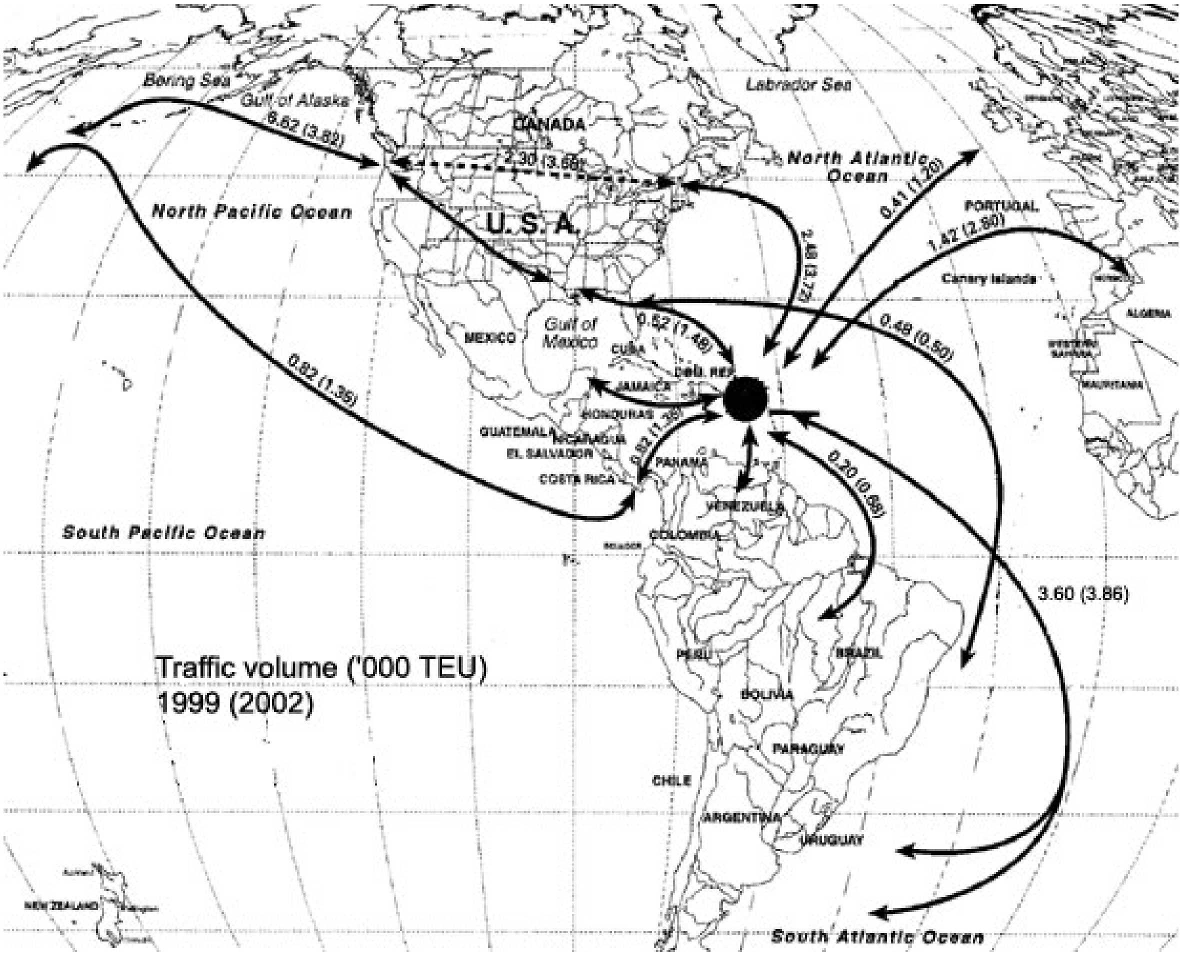
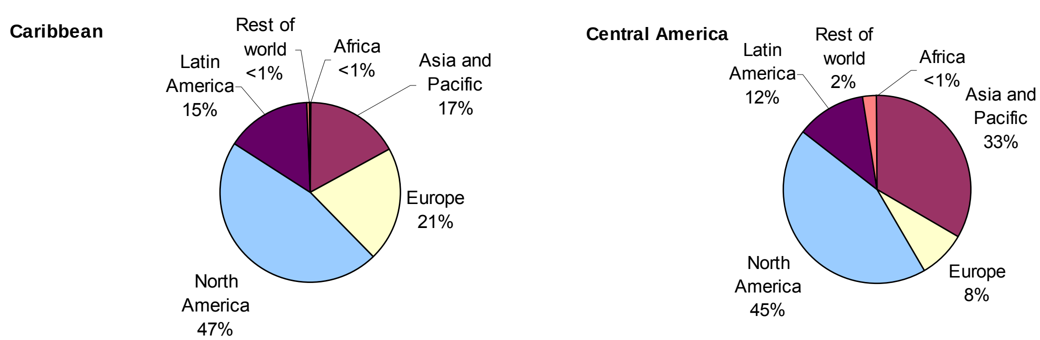


Figure 4.2 Origin of shipping containers (TEU) arriving in the Caribbean and Central America in 2006 (Sánchez and Ulloa, 2006).



Note: It was not specified if the containers were for import only or if the number of TEUs included transshipment containers. Latin America includes Mexico and the Caribbean; however, it was not noted whether all countries in the Caribbean region were included in the percentage for Latin America.

Table 4.1 Rankings of individual ports in the Greater Caribbean Region against ports worldwide in 2005 (Degerlund, 2007).

Port	Country	Million TEU	Worldwide rank	Percent change between 2004 and 2005
San Juan	Puerto Rico	1.7	53	+3.6
Kingston	Jamaica	1.7	56	+22.8
Houston, Texas	USA	1.6	59	+9.8
Puerto Manzanillo	Panama	1.6	60	+7.3
Freeport	Bahamas	1.2	71	+2.3
Miami, Florida	USA	1.1	80	+4.5
Coco Solo	Panama	0.8	90	+92.0
Jacksonville, Florida	USA	0.8	95	+6.8
Puerto Limon	Costa Rica	0.7	106	+3.2
Balboa	Panama	0.7	111	+42.7
Puerto Cortes	Honduras	0.5	136	+0.4
Santo Tomas de Castilla	Guatemala	0.3	170	-21.4
Port of Spain	Trinidad and Tobago	0.3	171	-8.0
Havana	Cuba	0.3	176	+22.3
New Orleans, Louisiana	USA	0.3	181	-7.1
Rio Haina	Dominican Republic	0.3	192	-38.2
Puerto Barrios	Guatemala	0.2	201	-1.2
Palm Beach, Florida	USA	0.2	204	+3.7
Puerto Quetzal	Guatemala	0.2	208	+22.1
Gulfport, Mississippi	USA	0.2	235	-12.1

Table 4.2 Countries in the Greater Caribbean Region (excluding the United States) that ranked within the top 60 for container traffic at maritime ports, based on a survey conducted at 500 maritime ports worldwide (Degerlund, 2007).

Country	2005		Percent change (from 2004 to 2005)
	TEU [1]	Rank	
Panama	3,067,637 [2]	27	+26.3
Puerto Rico	1,727,389	34	+3.7
Jamaica	1,670,820	35	+22.8
Bahamas	1,211,500	45	+2.3
Colombia	1,165,255 [3]	47	+23.1
Venezuela	1,120,492	48	+21.6
Costa Rica	778,651	54	+6.1
Guatemala	776,395	55	-6.1
Honduras	553,013	60	-0.5

[1] The number of TEU includes both international and domestic traffic and transshipped containers were counted twice.
[2] This total excludes container traffic at the port of Cristobal, Panama.
[3] This total excludes container traffic at the port of Santa Marta, Colombia.

Table 4.3 Commodities carried by small vessels (adapted from Boerne, 1999).

Cargo type	Percentage of small vessels involved in transport, grouped according to the length of the ship in feet[1]						
	30-39 ft.	40-49 ft.	50-59 ft.	60-69 ft.	70-79 ft.	80-89 ft.	90-99 ft.
Fruit	75	66	75	60	66	100	75
Vegetables	50	66	75	60	33	100	75
Horticulture goods	--	--	--	20	--	--	--
Individuals' packages	100	77	100	60	100	100	100
General cargo	25	66	75	40	100	100	100

[1]Twenty-nine small vessel crews were interviewed from the following countries: St. Maarten, Anguilla, St. Christopher (St. Kitts and Nevis), Dominica, St. Lucia, Barbados, St. Vincent, Bequia (St. Vincent and the Grenadines), Mystique (Martinique), Union Island (St. Vincent and the Grenadines), Petite Martinique (St. Vincent and the Grenadines), Carricou (St. Vincent and the Grenadines), Grenada (St. Vincent and the Grenadines), and Trinidad.

Table 4.4 Container traffic at maritime ports in the Caribbean region, 2003-2006.

Country [1]	Port	2003	Unit [2]	2004	Unit [2]	2005	Unit [2]	2006	Unit [2]	Data source
Aruba	**Oranjestad**	16,470	container boxes	16,461	container boxes	52,149	TEU total	17,659	container boxes	(Degerlund, 2007, Aruba Ports Authority, 2008)
Bahamas	**Freeport (Container Terminal)**	1,060,000	TEU total	1,184,800	TEU total	1,211,476	TEU total	1,385,860	TEU total	**2003:** (UNCTAD, 2005); **2004-2006:** (Degerlund, 2007)
Barbados	**Bridgetown**	70,146	TEU	82,059	TEU	88,759	TEU	92,507	TEU	**2003:** (CEPAL, 2007); **2004-2006:** (Degerlund, 2007)
Belize	**Belize City**	33,789	TEU total	35,565	TEU total	36,388	TEU total	37,527	TEU total	**2003-2006:** (Port of Belize, 2008); **2004:** (Degerlund, 2007)
	Commerce Bight									[No data found for this port]
Cayman Islands	**Georgetown**			49,670	TEU total	73,346	TEU total	59,281	TEU total	(Cayman Islands Port Authority, 2008)
	Cayman Brac									[No data found for this port]
Colombia	**Not specified**	995,203	TEU	1,073,081	TEU					(UNCTAD, 2005, 2006)
	Barranquilla, Santa Maria									[No data found for these specific ports]
	Cartagena	510,000	TEU total							(UNCTAD, 2005)
Costa Rica	**Ports combined**	667,275	TEU total	734,088	TEU total	740,420	TEU total	834,325	TEU total	**2003-2004:** (UNCTAD, 2005, 2006); **2005:** (CEPAL, 2007, INCOP, 2007); **2006:** (COCATRAM, 2007)
	Caldera	57,275	TEU total	66,744	TEU total	51,857	TEU total	68,649	TEU total	**2003-2005:** (CEPAL, 2007); **2005-2006:** (INCOP, 2007)
	Limón-Moín	610,000	TEU total	667,344	TEU total	688,563	TEU total	765,676	TEU total	**2003:** (UNCTAD, 2005); **2004-2005:** (CEPAL, 2007); **2006:** (COCATRAM, 2007)
	Puntarenas; Terminal Punta Morales									[No data found for these specific ports]
Cuba	**Havana**	216,587	TEU total	259,328	TEU total	317,105	TEU total			**2003:** (UNCTAD, 2005, 2006); **2004-2005:** (Degerlund, 2007)
	Mariel									[No data found for this port]
Curaçao	**Not specified**	81,212	TEU total	82,087	TEU total	89,229	TEU total	90,759	TEU total	(Curaçao Ports Authority, 2008)
Dominica	**Roseau**			7,724	TEU total	12,826	TEU	11,097	TEU total	(Degerlund, 2007)

Country [1]	Port	2003	Unit [2]	2004	Unit [2]	2005	Unit [2]	2006	Unit [2]	Data source
							total			
Dominican Republic	**Ports combined**	474,986	TEU total	537,316	TEU total	355,404	TEU total			**2003:** (UNCTAD, 2005); **2004-2005:** (CEPAL, 2007)
	Azua; Barahona; Haina Occidental; Pedernales; Samaná; San Pedro de Macorís									[No data found for these specific ports]
	Caucedo									[Note: In 2007, 80,689 containers entered (Dominican Republic Port Authority, 2008)]
	Haina Oriental									[Note: In 2007, 47,644 containers entered (Dominican Republic Port Authority, 2008)]
	La Romana	928	TEU	1,229	TEU	1,397	TEU			(CEPAL, 2007)
	Rio Haina	390,000	TEU	435,200	TEU total	268,738	TEU total			**2003:** (UNCTAD, 2005); **2004-2005:** (CEPAL, 2007)
	Puerto Plata	35,659	TEU	42,397	TEU	47,119	TEU			(CEPAL, 2007)
	Santo Domingo	30,182	TEU	31,156	TEU total	11,244	TEU total			(CEPAL, 2007)
	Boca Chica	14,417	TEU	25,712	TEU total	26,906	TEU total			(CEPAL, 2007)
	Manzanillo	3,800	TEU	1,622	TEU					(CEPAL, 2007)
El Salvador	**Acajutla**	66,216	TEU	92,857	TEU total	103,483	TEU total	113,990	TEU total	**2003:** (CEPAL, 2007); **2004-2006:** (Degerlund, 2007); **2006:** (Port of Acajutla, 2008)
Guatemala	**Ports combined**	725,976	TEU total	838,451	TEU total	776,662	TEU total	835,253	TEU total	**2003:** (CEPAL, 2007); **2004-2005:** (Degerlund, 2007); **2006:** (COCATRAM, 2007)
	Santo Tomas de Castilla	312,154	TEU	411,153	TEU total	323,045	TEU total	336,816	TEU total	**2003:** (CEPAL, 2007); **2004-2005:** (Degerlund, 2007);

Country [1]	Port	2003	Unit [2]	2004	Unit [2]	2005	Unit [2]	2006	Unit [2]	Data source
										2006: (COCATRAM, 2007)
	Barrios	242,112	TEU	232,242	TEU total	229,448	TEU total	236,003	TEU total	**2003-2005:** (CEPAL, 2007); **2006:** (COCATRAM, 2007)
	Quetzal	171,710	TEU	195,056	TEU total	224,169	TEU total	262,434	TEU total	**2003-2005:** (CEPAL, 2007); **2006:** (COCATRAM, 2007)
	San José									[No data not found for this port]
Guadeloupe	**Ports combined**	110,073	TEU total	224,529	TEU total	154,263	TEU total			**2003-2004:** (UNCTAD, 2005, 2006); **2003:** (Port of Guadeloupe, 2008); **2003-2005:** (CEPAL, 2007)
	Basse-Terre	1,805	TEU	2,274	TEU					(Port of Guadeloupe, 2008)
	Jarry	108,066	TEU	106,213	TEU	154,263	TEU			(CEPAL, 2007)
	Pointe-a-Pitre	202	TEU	116,042	TEU total	154,263	TEU total			**2003:** (CEPAL, 2007); **2004-2005:** (Degerlund, 2007)
Haiti	**Not specified**	470,567	TEU	555,489	TEU					(UNCTAD, 2005, 2006)
	Cap Haitien, Port au Prince									[No data found for these specific ports]
Honduras	**Ports combined**	1,208,526	TEU total	555,595	TEU total	553,013	TEU total	593,694	TEU total	**2003:** (UNCTAD, 2005, COCATRAM, 2007); **2004:** (Degerlund, 2007); **2005:** (CEPAL, 2007); **2006:** (COCATRAM, 2007)
	Not specified	400,000	TEU							(UNCTAD, 2005)
	Cortés	1,137,798	TEU	466,697	TEU total	468,563	TEU total	507,980	TEU total	**2003:** (COCATRAM, 2007); **2004-2005:** (Degerlund, 2007); **2006:** (COCATRAM, 2007)
	Castilla	69,451	TEU	88,792	TEU total	84,450	TEU total	85,714	TEU total	**2003-2005:** (CEPAL, 2007); **2006:** (COCATRAM, 2007)
	La Ceiba; Roatán; Tela									[No data found for these specific ports]
	San Lorenzo	1,277	TEU	106	TEU					(CEPAL, 2007)
Jamaica	**Ports combined**	1,279,908	TEU total	1,356,034	TEU total	1,670,800	TEU total			**2003:** (UNCTAD, 2005); **2003-2005:** (CEPAL, 2007); **2004-2005:** (Degerlund, 2007)

Country [1]	Port	2003	Unit [2]	2004	Unit [2]	2005	Unit [2]	2006	Unit [2]	Data source
	Kingston	1,137,798	TEU total	1,356,034	TEU total	1,670,800	TEU total			**2003:** (UNCTAD, 2005, CEPAL, 2007); **2004-2005:** (Degerlund, 2007)
	Montego Bay; Ocho Rios; Port Antonio									[No data found for these specific ports]
	other outports	142,110	TEU							(UNCTAD, 2005)
Netherland Antilles	**Not specified**	1,605,074	TEU							(UNCTAD, 2005)
Nicaragua	**Ports combined**	12,328	TEU total	16,983	TEU total	18,002	TEU total	46,968	TEU total	**2003-2004:** (COCATRAM, 2007, EPN, 2008); **2005-2006:** (EPN, 2008)
	Arlen Siu	1,198	TEU	1,046	TEU			795	TEU entering	(COCATRAM, 2007)
	Corinto	10,936	TEU	15,675	TEU	18,002	TEU	46,052	TEU	**2003-2004:** (COCATRAM, 2007, EPN, 2008); **2005-2006:** (EPN, 2008)
	El Bluff	194	TEU total	262	TEU total			121	TEU entering	(COCATRAM, 2007)
	Cabezas; El Rama; Sandino; San Juan del Sur									[No data found for these specific ports]
Panama	**Ports combined**	2,994,339	TEU total	2,929,023	TEU total	3,064,264	TEU total			
	Almirante	13,948	TEU	16,781	TEU	13,235	TEU	4,242	TEU entering	**2003-2005:** (CEPAL, 2007); **2006:** (COCATRAM, 2007)
	Balboa	1,510,000	TEU	465,091	TEU total	664,185	TEU total	958,583	TEU total	**2003:** (UNCTAD, 2005); **2004-2005:** (CEPAL, 2007); **2006:** (COCATRAM, 2007)
	Chiriqui Grande Terminal	8,212	TEU	3,178	TEU			2,606	TEU total	**2003-2004:** (CEPAL, 2007); **2006:** (COCATRAM, 2007)
	Colon includes Manzanillo, Evergreen, Panama Port	1,670,000	TEU	1,943,712	TEU	2,054,285	TEU	1,331,267	TEU total	**2003:** (UNCTAD, 2005); **2004-2005:** (CEPAL, 2007); **2006:** (COCATRAM, 2007)
	Colon Port	1,333	TEU	2,062	TEU					(COCATRAM, 2007)

Country [1]	Port	2003	Unit [2]	2004	Unit [2]	2005	Unit [2]	2006	Unit [2]	Data source
	Terminal									
	Colon Container Terminal	335,066	TEU	420,122	TEU total	806,195	TEU total	614,036	TEU total	**2003:** (COCATRAM, 2007); **2004-2005:** (Degerlund, 2007); **2006:** (COCATRAM, 2007)
	Cristobal			48,369	TEU total			80,799	TEU total	**2004:** (Degerlund, 2007); **2006:** (COCATRAM, 2007)
	Manzanillo International Terminal	1,125,780	TEU	1,459,960	TEU total	1,580,649	TEU total	1,331,267	TEU total	(COCATRAM, 2007, MIT, 2008)
	Panama Ports Company			513,460	TEU			49,133	TEU entering	(COCATRAM, 2007)
	Terminal Samba Bonita			37	TEU					(COCATRAM, 2007)
	Aguadulce; Amador; Armuelles; Charco Azul; Pedregal; Terminal Decal; Terminal Granelera; Terminal Petrolero (Bahia las Minas)									[No data found for these specific ports]
Puerto Rico	**San Juan**			1,667,868	TEU total	1,727,389	TEU total			(Degerlund, 2007)
St. Lucia	**Ports combined**	24,090	TEU total	27,359	TEU total	33,722	TEU total	34,133	TEU total	(SLASPA, 2007)
	Port Castries	19,248	TEU total	21,302	TEU total	25,719	TEU total	21,374	TEU total	(SLASPA, 2007)
	Port Vieux-Fort	4,842	TEU total	6,057	TEU total	8,003	TEU total	12,759	TEU total	(SLASPA, 2007)
St. Martin	**Not specified**	440,368	TEU							(UNCTAD, 2005)
Trinidad and Tobago	**Ports combined**	396,368	TEU total	449,468	TEU total	322,466	TEU total			(CEPAL, 2007)

Country [1]	Port	2003	Unit [2]	2004	Unit [2]	2005	Unit [2]	2006	Unit [2]	Data source
	Port-of-Spain	298,000	TEU	350,468	TEU total	322,466	TEU total			(CEPAL, 2007)
	Port Point Lisas	98,368	TEU	99,000	TEU total					(CEPAL, 2007)
Florida (U.S.)	**Miami**	1,041,483	TEU	1,009,500	TEU	1,054,462	TEU	976,514	TEU	(Port of Miami-Dade, 2008)
	Jacksonville	692,422	TEU	727,660	TEU	777,318	TEU	768,239	TEU	(Jacksonville Port Authority, 2008)
	Palm Beach	224,952	TEU total	222,300	TEU total	239,822	TEU total	241,356	TEU total	(Port of Palm Beach, 2008)
	Port Everglades	569,743	TEU total	653,628	TEU total	797,238	TEU total	864,030	TEU total	(Port Everglades, 2008)
Alabama (U.S.)	**Not specified**	37,375	TEU	42,443	TEU	68,823	TEU	108,572	TEU	(Alabama State Port Authority, 2008)
Louisiana (U.S.)	**Port of New Orleans**			323,060	TEU	300,000	TEU			(Degerlund, 2007)
Mississippi (U.S.)	**Port of Gulfport**							48,751	containers entering	(Mississippi State Port Authority, 2008)
Texas (U.S.)	**Freeport**	34,816	TEU entering	32,910	TEU entering	38,192	TEU entering	38,226	TEU entering	(Port of Freeport, 2008)
	Port of Houston Authority			1,440,478	TEU	1,582,081	TEU	800,000	TEU entering	**2004-2005:** (Degerlund, 2007); **2006:** (Port of Houston, 2008)

[1] Data for the following countries were not available for the years presented in the table: Anguilla, Antigua and Barbuda, British Virgin Islands, Bonaire, Grenada, Guyana, Martinique, Montserrat, St. Kitts and Nevis, St. Maarten, St. Vincent and the Grenadines, Suriname, Turks and Caicos Islands, and the U.S. Virgin Islands.
[2] “TEU” (twenty foot equivalent) is the standard unit of measurment for sea cargo containers. In the table, “TEU total” is the total number of TEUs, full or empty, imported or exported, that passes through the port (often but not always excludes transshipment containers). Not all of the data sources define whether the reported number of TEUs includes arriving or exiting or both, full or empty or both.

Table 5.1 Reportable pests intercepted in aircraft cargo stores, quarters, or holds at U.S. ports of entry between January 1, 1997 and December 31, 2007 (USDA, 2008d).

Order and Family	Pest	Number intercepted
ARTHROPODS		
COLEOPTERA		
Bostrichidae	Bostrichidae	3
Cerambycidae	*Acanthoderes* sp.	1
	Cerambycidae	1
Chrysomelidae	*Acalymma* sp.	3
	Altica sp.	1
	Alticinae	3
	Aphthona sp.	1
	Aulacophora indica	1
	Aulacophora nigripennis	1
	Cassidinae	1
	Chaetocnema sp.	1
	Chrysomelidae	8
	Colaspis lebasi	1
	Colaspis sp.	19
	Diabrotica viridula	1
	Disonycha sp.	1
	Epitrix sp.	1
	Eumolpinae	5
	Exora encaustica	1
	Exora sp.	1
	Galerucinae	4
	Leptinotarsa tlascalana	1
	Longitarsus sp.	1
	Lysathia sp.	1
	Malacorhinus irregularis	1
	Metachroma sp.	1
	Myochrous sp.	1
	Oedionychus sp.	1
	Rhabdopterus sp.	4
	Systena s-littera	1
	Talurus sp.	1
	Tetragonotes sp.	1
	Timarcha sp.	1
	Typophorus sp.	2
Curculionidae	Apioninae	1
	Brachycerinae	1
	Cleogonus fratellus	2
	Cleogonus sp.	1
	Conotrachelus sp.	6
	Cryptorhynchinae	1
	Curculio sp.	1
	Curculionidae	13
	Eulechriops sp.	1
	Myllocerus undatus	2
	Naupactus xanthographus	1
	Phyrdenus sp.	1
	Pityophthorus sp. (Scolytinae)	1
	Rhynchophorinae	2
	Rhyssomatus sp.	1
Dryophthoridae	*Metamasius hemipterus*	2
Elateridae	*Aeolus nigromaculatus*	1
	Aeolus sp.	2
	Conoderus pictus	1
	Conoderus pilatei	1
	Conoderus rodriguezi	2
	Conderus sp.	2
	Conoderus varians	4
	Elateridae	5
Meloidae	*Epicauta* sp.	2
	Meloidae	2
Scarabaeidae	*Adoretus* sp.	1
	Amphimallon solstitialis	1

Order and Family	Pest	Number intercepted
	Amphimallon sp.	1
	Ancognatha castanea	1
	Ancognatha scarabaeoides	8
	Ancognatha sp.	45
	Ancognatha ustulata	10
	Anomala sp.	44
	Archophileurus sp.	1
	Athlia rustica	1
	Barybas sp.	1
	Blitopertha sp.	1
	Bothynus sp.	1
	Ceraspis centralis	1
	Ceraspis sp.	4
	Clavipalpus sp.	2
	Cyclocephala amazona	1
	Cyclocephala mafaffa	2
	Cyclocephala sp.	65
	Diplotaxis sp.	27
	Dynastes hercules	1
	Dynastinae	13
	Dyscinetus sp.	5
	Euetheola bidentata	3
	Euetheola sp.	8
	Euphoria sp.	6
	Geniates panamaensis	4
	Geniates sp.	7
	Leucothyreus sp.	3
	Liogenys macropelma	22
	Liogenys quadridens	3
	Liogenys sp.	13
	Maladera sp.	1
	Manopus sp.	5
	Melolonthinae	23
	Phyllophaga sp.	167
	Plectris sp.	21
	Rutelinae	3
	Scarabaeidae	5
	Serica sp.	1
	Stenocrates sp.	1
	Tomarus sp.	32
Tenebrionidae	*Blapstinus* sp.	44
	Epitragus sp.	4
	Lagriinae	1
	Lobometopon sp.	1
	Opatrinus pullus	1
	Tenebrionidae	1
DIPTERA		
Agromyzidae	Agromyzidae	1
Chloropidae	Chloropidae	3
Tephritidae	*Anastrepha* sp.	1
	Ceratitis capitata	1
HEMIPTERA		
Achilidae	Achilidae	1
Aleyrodidae	Aleyrodidae	1
Alydidae	*Camptopus lateralis*	1
Aphididae	Aphididae	3
	Dysaphis sp.	1
	Macrosiphum sp.	1
Aphrophoridae	Aphrophoridae	1
Cercopidae	*Aeneolamia reducta*	2
Cicadellidae	*Aphrophora* sp.	1
	Cercopidae	4
	Clastoptera sp.	1
	Prosapia sp.	4
	Tomaspis sp.	1
	Agallia sp.	2
Cicadidae	*Chlorotettix* sp.	5
	Cicadellidae	16
	Deltocephalinae	3

Order and Family	Pest	Number intercepted
	Empoasca sp.	2
	Exitianus sp.	1
	Graphocephala sp.	1
	Haldorus sp.	1
	Oncometopia sp.	1
	Texananus sp.	1
	Typhlocybinae	1
	Xerophloea sp.	1
	Xestocephalus sp.	2
	Cicadidae	3
Cixiidae	Cixiidae	5
	Myndus sp.	1
	Pintalia sp.	2
Cydnidae	Cydnidae	13
	Dallasiellus bacchinus	12
	Dallasiellus sp.	1
	Melanaethus spinolai	1
	Pangaeus rugiceps	5
Delphacidae	Delphacidae	9
	Nilaparvata lugens	1
Diaspididae	*Parlatoria ziziphi*	1
Lygaeidae	Lygaeidae	8
	Nysius sp.	10
Membracidae	Membracidae	1
Miridae	*Eurychilella* sp.	3
Pachygronthidae	Miridae	15
	Platylygus sp.	1
	Pycnoderes sp.	1
	Tropidosteptes chapingoensis	1
	Oedancala notata	1
Pentatomidae	*Acrosternum* sp.	1
Psyllidae	*Banasa* sp.	1
	Berecynthus hastator	1
	Euschistus sp.	2
	Macropygium reticulare	1

Order and Family	Pest	Number intercepted
	Macropygium sp.	2
	Oebalus insularis	1
	Pentatomidae	5
	Piezodorus lituratus	1
	Rhaphigaster nebulosa	1
	Psylla sp.	1
Pyrrhocoridae	*Dysdercus* sp.	1
	Pyrrhocoridae	1
Rhopalidae	Rhopalidae	1
Rhyparochromidae	*Cistalia* sp.	1
	Cryphula sp.	1
	Heraeus sp.	1
	Myodocha sp.	1
	Neopamera sp.	2
	Ozophora sp.	1
	Paragonata divergens	4
	Paromius sp.	1
	Prytanes sp.	5
	Rhyparochromidae	6
	Valtissius sp.	1
Scutelleridae	Scutelleridae	1
	Tetyra sp.	1
Not specified	Hemiptera	1
HYMENOPTERA		
Formicidae	*Atta cephalotes*	2
	Atta sexdens	5
	Atta sp.	7
	Formicidae	1
	Myrmicinae	4
	Pheidole sp.	2
	Solenopsis sp.	1
ISOPTERA		
Termitidae	*Nasutitermes ephratae*	2
	Termitidae	2
LEPIDOPTERA		

Order and Family	Pest	Number intercepted
Acrolophidae	Acrolophidae	1
	Acrolophus sp.	2
Arctiidae	Arctiidae	23
	Creatonotus transiens	1
	Ctenuchinae	2
	Ecpantheria sp.	1
	Estigmene sp.	1
Argyresthiidae	Argyresthiidae	1
Crambidae	Crambidae	8
	Crambus sp.	1
	Diaphania sp.	1
	Euchromius sp.	1
	Herpetogramma sp.	1
	Mesocondyla dardanalis	1
	Pyraustinae	10
	Samea ecclesialis	1
Ctenuchidae	Ctenuchidae	4
Elachistidae	Elachistidae	1
Gelechiidae	Gelechiidae	18
Geometridae	*Eupithecia* sp.	1
	Geometridae	23
Gracillariidae	*Phyllocnistis* sp.	1
Hesperiidae	Hesperiidae	1
Megalopygidae	*Norape* sp.	1
Noctuidae	Acontinae	1
Notodontidae	Agaristinae	1
	Agrotis sp.	2
	Bulia sp.	1
	Copitarsia sp.	4
	Earias insulana	1
	Eulepidotis guttata	5
	Gonodonta sp.	3
	Helicoverpa armigera	1
	Herminiinae	1
	Hypena sp.	1

Order and Family	Pest	Number intercepted
	Letis sp.	1
	Leucania inconspicua	1
	Melipotis sp.	4
	Noctuidae	342
	Plusiinae	3
	Spodoptera cosmioides	1
	Spodoptera sp.	4
	Notodontidae	4
Nymphalidae	Nymphalidae	3
Oecophoridae	*Ethmia* sp.	1
	Oecophoridae	1
Pyralidae	Phycitinae	3
	Pyralidae	68
Saturniidae	Saturniidae	1
Sesiidae	Sesiidae	2
Sphingidae	*Erinnyis* sp.	1
	Sphingidae	27
Tineidae	Tineidae	13
Tortricidae	*Crocidosema aporema*	1
	Tortricidae	2
Not specified	Gelechioidea	2
	Lepidoptera	12
	Pyraloidea	10
ORTHOPTERA		
Acrididae	Acrididae	1
	Dichromorpha sp.	1
	Metaleptea brevicornis	2
	Orphulella punctata	3
	Sphingonotus sp.	2
	Stenacris vitreipennis	1
	Trimerotropis sp.	1
Gryllidae	*Allonemobius* sp.	1
Gryllotalpidae	*Anaxipha* sp.	7
	Eneopterinae	1

Order and Family	Pest	Number intercepted
	Gryllidae	8
	Gryllus capitatus	1
	Gryllus sp.	119
	Lerneca varipes	1
	Nemobiinae	1
	Ornebius sp.	1
	Paroecanthus sp.	1
	Pteronemobius sp.	2
	Gryllotalpa sp.	1
Pyrgomorphidae	*Atractomorpha sinensis*	1
	Atractomorpha sp.	1
Romaleidae	*Tropidacris cristata*	1
Tetrigidae	*Tetrix* sp.	2
	Tettigidea sp.	1
Tettigoniidae	*Bucrates capitatus*	1
	Bucrates sp.	1
	Conocephalus saltator	1
	Conocephalus sp.	16
	Copiphora sp.	1
	Microcentrum concisum	1
	Microcentrum sp.	1
	Neoconocephalus punctipes	2
	Neoconocephalus sp.	24
	Platycleis afghana	3
	Subria sp.	1
	Tettigoniidae	11
MOLLUSK		
PULMONATA		
Helicidae	*Cornu aspersum*	1

[1] This table does not include pest interceptions made on military aircraft or questionable records.

Table 5.2 Aircraft arrivals in the Greater Caribbean Region.

Country or territory	Aircraft arrivals	Comments	Reference
Bonaire	15,249	Data from 2007.	(Bonaire International Airport, 2008)
Cayman Islands	27,800	Data from 2005. Includes international, domestic, and private flights.	(Cayman Islands Economics and Statistics Office, 2007)
Dominican Republic	65,462	Data from 2004. Includes regular and charter international flights.	(República Dominicana Oficina Nacional de Estadística, 2004)
El Salvador	14,236	Data from 2006. Reported as the number of landings.	(International Airport of El Salvador, 2007)
Jamaica	69,525	Data from 2006. Reported as the number of air movements.	(Airports Authority of Jamaica, 2008)
Puerto Rico	20,873	Data from 2007. Reported as number of foreign aircraft departures arriving in Puerto Rico (excludes aircraft from the continental United States and other U.S. territories).	(US-DOT, 2007)
St. Lucia	47,829	Data from 2006.	(SLASPA, 2007)
St. Maarten	107,581	Data from 2006.	(Sint Maarten International Airport, 2008)
U.S. Virgin Islands	29,298	Data from 2006.	(U.S. Virgin Islands Port Authority, 2006)
U.S. Gulf Coast states (Alabama, Florida, Louisiana, Mississippi, Texas)	167,814	Data from 2007. Reported as the number of foreign aircraft departures arriving in these states.	(US-DOT, 2007)

Table 5.3 Live hitchhiking pests intercepted at U.S. maritime ports of entry between January 1997 and December 2007 on ships, ship decks, ship holds, ship stores, ship quarters, containers, and non-agricultural cargo (USDA, 2008d).

Pest	Where intercepted
Plant pathogen	
Cladosporium sp. (Hyphomycetes)	Marble
Fusarium sp. (Hyphomycetes)	Marble
Phoma sp. (Coelomycetes)	Tiles
Insect	
Acanthoscelides sp. (Bruchidae)	Tiles
Acheta sp., *A. hispanicus* (Gryllidae)	Quarry product, tiles
Acroleucus sp. (Lygaeidae)	Tiles
Acrosternum sp., *A. heegeri* (Pentatomidae)	Container, quarry product, tiles
Aelia acuminata, *A. virgata* (Pentatomidae)	Container, marble, tiles
Agallia sp. (Cicadellidae)	Tiles
Agriotes sp., *A. lineatus* (Elateridae)	Tiles
Akis sp. (Tenebrionidae)	Tiles
Alitocoris parvus (Pentatomidae)	Tiles
Altica sp. (Chrysomelidae)	Ceramic, container, steel, marble, tiles
Amnestus sp. (Cydnidae)	Tiles
Amphiacusta caraibea (Gryllidae)	Tiles
Anaceratagallia sp., *A. venosa* (Cicadellidae)	Tiles
Anacridium aegyptium (Acrididae)	Quarry product, tiles
Anaxipha sp. (Gryllidae)	Tiles
Anomala sp. (Scarabaeidae)	Military vehicles, tiles
Anthaxia sp. (Buprestidae)	Marble, tiles
Anthonomus sp. (Curculionidae)	Tiles
Aphanus rolandri (Rhyparochromidae)	Tiles
Aphrodes sp. (Cicadellidae)	Tiles
Aphthona sp., *A. euphorbiae* (Chrysomelidae)	Limestone, tiles
Apion sp. (Apionidae)	Bricks, limestone, machinery, marble, ship stores, tiles
Apis sp., *A. mellifera* (Apidae)	Ceramic, container, quarry product, tiles
Arachnocephalus vestitus (Mogoplistidae)	Tiles
Araecerus sp. (Anthribidae)	Granite, tiles
Arge sp. (Argidae)	Machinery
Arhyssus sp. (Rhopalidae)	Stones
Arocatus sp., *A. melanocephalus*, *A. longiceps*, *A. roeselii* (Lygaeidae)	Ceramic tiles, container, marble, tiles
Asiraca clavicornis (Delphacidae)	Tiles
Athalia cordata (Tenthredinidae)	Tiles
Athetis sp. (Noctuidae)	Tiles
Athous sp. (Elateridae)	Tiles
Aulacophora sp., *A. indica* (Chrysomelidae)	Automobile, container, tractor
Bagrada sp. (Pentatomidae)	Tiles
Balanagastris kolae (Curculionidae)	Tractor
Bangasternus planifrons (Curculionidae)	Tiles
Baris sp. (Curculionidae)	Tiles
Beosus maritimus, *B. quadripunctatus* (Rhyparochromidae)	Marble, quarry product, tiles
Blapstinus sp. (Tenebrionidae)	Metal, stones, tiles
Blissus sp. (Blissidae)	Tiles
Brachycerus algirus (Curculionidae)	Marble
Bruchidius sp., *B. bimaculatus*, *B. nudus*, *B. villosus* (Bruchidae)	Tiles
Bruchus sp. (Bruchidae)	Tiles
Buprestis sp., *B. dalmatina* (Buprestidae)	Tiles
Cacopsylla sp. (Psyllidae)	Tiles
Calliptamus italicus (Acrididae)	Tiles
Camponotus lateralis (Formicidae)	Marble, quarry product, tiles

Pest	**Where intercepted**
Capraita sp. (Chrysomellidae)	Machinery
Caprhiobia lineola (Lygaeidae)	Bricks
Cardiophorus sp. (Elateridae)	Tiles
Carphoborus sp. (Curculionidae: Scolytinae)	Tiles
Carpocoris pudicus (Pentatomidae)	Tiles
Cassida sp., *C. flaveola*, *C. prasina* (Chrysomelidae)	Tiles
Centrocoris spiniger, *C. variegatus* (Coreidae)	Tiles
Cercopis sanguinolenta (Cercopidae)	Tiles
Ceresium sp. (Cerambycidae)	Machinery
Ceutorhynchus sp. (Curculionidae)	Marble, tiles
Chaetocnema sp., *C. conducta*, *C. tibialis* (Chrysomelidae)	Granite, machinery, marble, tiles
Chelymorpha sp. (Chrysomelidae)	Tiles
Chlorophorus sp. (Cerambycidae)	Quarry product, granite
Chorthippus sp. (Acrididae)	Tiles
Chrysobothris sp. (Buprestidae)	Marble, tiles
Chrysolina sp. (Chrysomelidae)	Tiles
Chydarteres sp. (Cerambycidae)	Tiles
Cicadella sp., *C. viridis* (Cicadellidae)	Tiles
Cinara sp. (Aphididae)	Container
Clastoptera sp. (Cercopidae)	Tiles
Cleonus sp. (Curculionidae)	Tiles
Clytus sp. (Cerambycidae)	Limestone, tiles
Coccotrypes sp. (Curculionidae: Scolytinae)	Aluminum
Colaspis sp. (Chrysomelidae)	Machinery, tiles
Conocephalus sp. (Tettigoniidae)	Marble
Conoderus sp., *C. rufangulus*, *C. varians* (Elateridae)	Marble, tiles, truck
Conotrachelus sp. (Curculionidae)	Tiles
Coraebus sp. (Buprestidae)	Tiles
Coreus marginatus (Coreidae)	Tiles
Coriomeris denticulatus (Coreidae)	Tiles
Corizus hyoscyami (Rhopalidae)	Tiles

Pest	**Where intercepted**
Cossonus sp. (Curculionidae)	Tiles
Crematogaster sp. (Formicidae)	Machinery, marble, quarry product, tiles
Crocistethus waltlianus (Cydnidae)	Tiles
Crophius sp. (Oxycarenidae)	Tiles
Cryphalus sp. (Curculionidae: Scolytinae)	Tiles
Cryptocephalus sp. (Chrysomelidae)	Tiles
Crypturgus sp. (Curculionidae: Scolytinae)	Stoneware
Cucullia sp. (Noctuidae)	Tiles
Curculio sp. (Curculionidae)	Machinery
Cyclocephala amazona, *C. mafaffa* (Scarabaeidae)	Container
Dasineura sp. (Cecidomyiidae)	Stones
Deltocephalus sp. (Cicadellidae)	Tiles
Dibolia sp. (Chrysomelidae)	Tiles
Dichroplus sp. (Acrididae)	Steel bars
Dicranocephalus sp. (Stenocephalidae)	Tiles
Diphaulaca sp. (Chrysomelidae)	Tiles
Disonycha sp. (Chrysomelidae)	Metal
Dolerus rufotorquatus (Tenthredinidae)	Tiles
Dolycoris baccarum (Pentatomidae)	Tiles
Donacia sp. (Chrysomelidae)	Granite
Dorytomus sp. (Curculionidae)	Tiles
Drasterius sp., *D. bimaculatus* (Elateridae)	Quarry product, tiles
Dryocoetes autographus (Curculionidae: Scolytinae)	Tiles
Dyscinetus sp. (Scarabaeidae)	Ship deck, ship holds, tiles
Dysdercus sp. (Pyrrhocoridae)	Tiles
Emblethis sp., *E. denticollis*, *E. griseus*, *E. verbasci* (Rhyparochromidae)	Container, tiles
Emmelia trabealis (Noctuidae)	Tiles
Epitragus sp. (Tenebrionidae)	Tiles
Epitrix sp. (Chrysomelidae)	Tiles

Pest	Where intercepted
Eremocoris sp., *E. fenestratus* (Rhyparochromidae)	Tiles
Etiella sp. (Pyralidae)	Machinery
Eurydema sp., *E. oleraceum*, *E. ornatum*, *E. ventrale* (Pentatomidae)	Quarry product, stones, tiles
Eurygaster sp. (Scutelleridae)	Tiles
Eurythyrea austriaca (Buprestidae)	Tiles
Eurytoma sp. (Eurytomidae)	Tiles
Euschistus sp. (Pentatomidae)	Tiles
Eutelia geyeri (Noctuidae)	Tires
Eysarcoris sp. (Pentatomidae)	Tiles
Eysarcoris ventralis (Pentatomidae)	Quarry product, tiles
Fromundus pygmaeus (Cydnidae)	Tiles
Galeruca sp. (Chrysomelidae)	Tiles
Galerucella sp. (Chrysomelidae)	Tiles
Galgupha albipennis (Cydnidae)	Tiles
Gastrodes abietum, *G. grossipes* (Rhyparochromidae)	Electrical parts, marble
Gastrophysa sp. (Chrysomelidae)	Tiles
Geotomus elongates, *G. punctulatus* (Cydnidae)	Tiles
Gnathotrichus sp. (Curculionidae: Scolytinae)	Tiles
Gonioctena sp., *G. fornicata* (Chrysomelidae)	Tiles
Gonocephalum sp. (Tenebrionidae)	Marble, tiles
Gonocerus sp., *G. venator* (Coreidae)	Tiles
Graphosoma sp., *G. italicum* (Pentatomidae)	Tiles
Graptostethus sp. (Lygaeidae)	Tiles
Gryllomorpha campestris, *G. dalmatina* (Gryllidae)	Quarry product, tiles
Gryllus sp. (Orthoptera: Gryllidae)	Container, marble, tiles
Gymnetron sp. (Curculionidae)	Tiles
Hesperophanes sp. (Cerambycidae)	Machinery, tiles
Heterobostrychus aequalis (Bostrichidae)	Tiles
Heterogaster artemisiae, *H. urticae* (Heterogastridae)	Machinery, marble, tiles, tractor
Hexarthrum sp. (Curculionidae)	Tiles

Pest	Where intercepted
Hippopsis sp. (Cerambycidae)	Ship deck
Holcostethus sp., *H. sphacelatus*, *H. strictus*, *H. vernalis* (Pentatomidae)	Marble, quarry product, tiles
Holocranum sp. (Artheneidae)	Tiles
Homalodisca sp. (Cicadellidae)	Tiles
Horvathiolus superbus (Lygaeidae)	Tiles
Hylastes sp., *H. ater*, *H. attenuatus*, *H. cunicularius*, *H. linearis* (Curculionidae: Scolytinae)	Electrical parts, stones, tiles
Hylobius sp. (Curculionidae)	Electrical parts, steel, tiles
Hylurgops sp., *H. palliatus* (Curculionidae: Scolytinae)	Electrical parts, machinery, tiles
Hylurgus sp., *H. ligniperda*, *H. micklitzi* (Curculionidae: Scolytinae)	Electrical parts, machinery, marble, tiles
Hypena sp., *H. rostralis* (Noctuidae)	Tiles
Hypera sp. (Curculionidae)	Limestone, stones, tiles
Hypocassida sp. (Chrysomelidae)	Tiles
Hypocryphalus sp. (Curculionidae: Scolytinae)	Tiles
Hypothenemus sp. (Curculionidae: Scolytinae)	Tiles
Idiocerus sp. (Cicadellidae)	Ceramic tiles, tiles
Ips sp., *I. acuminatus*, *I. erosus*, *I. mannsfeldi*, *I. sexdentatus*, *I. typographus* (Curculionidae: Scolytinae)	Container, electrical parts, marble, metal, slate, steel, tiles
Ischnodemus sp. (Blissidae)	Tiles
Kalotermes flavicollis (Kalotermitidae)	Marble, tiles
Kleidocerys sp. (Lygaeidae)	Machinery
Kytorhinus sp. (Bruchidae)	Tiles
Larinus sp. (Curculionidae)	Quarry product, stones, tiles
Liocoris tripustulatus (Miridae)	Tiles
Liriomyza sp. (Agromyzidae)	Tiles
Listronotus sp. (Curculionidae)	Ship deck, tiles

Pest	**Where intercepted**
Livilla sp. (Psyllidae)	Tiles
Lixus sp. (Curculionidae)	Container, machinery, tiles
Longitarsus sp. (Chrysomelidae)	Tiles
Lyctus sp. (Bostrichidae)	Machinery
Lygaeosoma sardeum (Lygaeidae)	Quarry product, tiles
Lygaeus creticus, *L. equestris* (Lygaeidae)	Tiles
Lygocoris sp. (Miridae)	Tiles
Lygus sp., *L. gemellatus*, *L. maritimus* (Miridae)	Tiles
Lymantria sp., *L. dispar* (Lymantriidae)	Automobile, container
Macroglossum stellatarum (Sphingidae)	Tiles
Magdalis sp., *M. frontalis* (Curculionidae)	Tiles
Mamestra brassicae (Noctuidae)	Tiles
Maruca vitrata (Crambidae)	Tiles
Mecinus circulatus (Curculionidae)	Tiles
Megalonotus chiragrus (Rhyparochromidae)	Ceramic tiles, container, marble, quarry product, ship stores, tiles
Melanocoryphus albomaculatus (Lygaeidae)	Ceramic tiles, quarry product, tiles
Melanophila sp., *M. cuspidata* (Buprestidae)	Tiles
Melanoplus sp. (Acrididae)	Marble
Melanotus sp. (Elateridae)	Tiles
Melipotis sp. (Noctuidae)	Tiles
Metopoplax sp., *M. orginai* (Oxycarenidae)	Marble, quarry product, tiles
Micrapate scabrata (Bostrichidae)	Mable, tiles
Micrelytra sp. (Alydidae)	Tiles
Microplax albofasciata (Oxycarenidae)	Stoneware
Microtheca sp. (Chrysomelidae)	Tiles
Microtomideus leucodermus (Lygaeidae)	Tiles

Pest	**Where intercepted**
Monochamus sp., *M. alternatus*, *M. galloprovincialis*, *M. sutor* (Cerambycidae)	Aluminum, automobile parts, granite, machinery, stones, tiles
Monosteira unicostata (Tingidae)	Mable, tiles
Myochrous sp. (Chrysomelidae)	Tiles
Myodocha longicollis (Rhyparochromidae)	Tiles
Nasutitermes sp., *N. costalis* (Termitidae)	Container, tiles
Nematocera, species of	Marble
Neonemobius sp. (Gryllidae)	Tiles
Neottiglossa sp. (Pentatomidae)	Tiles
Nezara sp. (Pentatomidae)	Tiles
Nilaparvata lugens (Delphacidae)	Tiles
Niphades sp. (Curculionidae)	Machinery
Nysius sp., *N. ericae* (Lygaeidae)	Ceramic tiles, limestone, marble, quarry product, stones, tiles
Ochrosis ventralis (Chrysomelidae)	Tiles
Ochrostomus sp. (Lygaeidae)	Tiles
Opatriodes sp. (Tenebrionidae)	Tiles
Opogona sp. (Tineidae)	Machinery
Orgyia sp. (Lymantriidae)	Tiles
Ornebius annulatus (Gryllidae)	Tiles
Orthotomicus laricis (Curculionidae: Scolytinae)	Limestone, marble tiles, tiles
Orthotomicus sp. (Curculionidae: Scolytinae)	Limestone
Otiorhynchus sp. (Curculionidae)	Limestone, tiles
Oulema sp. (Chrysomelidae)	Machinery, quarry product, tiles
Oxycarenus lavaterae, *O. pallens* (Oxycarenidae)	Tiles
Pachypsylla sp. (Psyllidae)	Machinery, tiles
Palomena prasina (Pentatomidae)	Tiles
Pandeleteius sp. (Curculionidae)	Tiles

Pest	Where intercepted
Parapoynx sp., *P. fluctuosalis* (Crambidae)	Quarry product, tiles
Paromius gracilis (Rhyparochromidae)	Quarry product, tiles
Paropsis sp. (Chrysomelidae)	Container
Peritrechus sp., *P. gracilicornis* (Rhyparochromidae)	Automobile, ceramic tiles, container, marble, quarry product, slate, tiles
Phaenomerus sp. (Curculionidae)	Tiles
Phaneroptera nana (Tettigoniidae)	Tiles
Philaenus sp. (Cercopidae)	Tiles
Phoracantha recurva (Cerambycidae)	Tiles
Phratora sp. (Chrysomelidae)	Tiles
Phyllobius sp. (Curculionidae)	Stones, tiles
Phyllonorycter sp. (Gracillariidae)	Tiles
Phyllophaga sp. (Scarabaeidae)	Tiles
Phyllotocus sp. (Scarabaeidae)	Tiles
Phyllotreta sp. (Chrysomelidae)	Ceramic tiles, tiles
Phymatodes sp. (Cerambycidae)	Machinery
Pieris sp., *P. brassicae* (Pieridae)	Container, steel, tiles, tractor
Piesma sp. (Piesmatidae)	Tiles
Piezodorus lituratus (Pentatomidae)	Tiles
Pintalia sp. (Cixiidae)	Tiles
Pissodes sp. (Curculionidae)	Tiles
Pityogenes sp., *P. chalcographus*, *P. quadridens* (Curculionidae: Scolytinae)	Marble, steel, tiles
Pityophthorus sp. (Curculionidae: Scolytinae)	Machinery
Plagiodera sp. (Chrysomelidae)	Tiles
Platyplax sp., *P. salviae* (Heterogastridae)	Tiles
Podagrica sp. (Chrysomelidae)	Tiles
Polydrusus sp. (Curculionidae)	Marble
Polygraphus poligraphus (Curculionidae: Scolytinae)	Tiles
Prytanes sp. (Rhyparochromidae)	Tiles

Pest	Where intercepted
Pselactus sp. (Curculionidae)	Limestone
Psylliodes sp. (Chrysomelidae)	Limestone, tiles
Pteronemobius sp. (Gryllidae)	Tiles
Puto superbus (Pseudococcidae)	Marble, stones
Pyrrhalta sp. (Chrysomelidae)	Tiles
Pyrrhocoris apterus (Pyrrhocoridae)	Ceramic tiles, limestone, marble, stones, tiles
Raglius alboacuminatus (Rhyparochromidae)	Machinery, tiles
Remaudiereana annulipes (Rhyparochromidae)	Tiles
Reticulitermes lucifugus (Rhinotermitidae)	Granite, tiles
Rhaphigaster nebulosa (Pentatomidae)	Ceramic, ceramic tiles, container, limestone, machinery, marble, quarry product, tiles
Rhopalus subrufus (Rhopalidae)	Quarry product, tiles
Rhynchaenus sp. (Curculionidae)	Tiles
Rhyncolus sp. (Curculionidae)	Tiles
Rhyparochromus sp., *R. adspersus*, *R. confusus*, *R. quadratus*, *R. saturnius*, *R. vulgaris* (Rhyparochromidae)	Limestone, machinery, quarry product, tiles
Rhytidoderes plicatus (Curculionidae)	Ceramic, ship holds, tiles
Scantius aegyptius (Pyrrhocoridae)	Tiles
Sciocoris cursitans, *S. maculatus* (Pentatomidae)	Marble, quarry product, tiles
Scolopostethus sp., *S. affinis*, *S. decoratus*, *S. pictus* (Rhyparochromidae)	Tiles
Sehirus sp., *S. bicolor* (Cydnidae)	Tiles
Sinoxylon sp., *S. anale*, *S. conigerum* (Bostrichidae)	Granite, limestone, machinery, marble, metal, steel, tiles

Pest	Where intercepted
Sirex noctilio (Siricidae)	Marble, tiles, steel
Sitona sp., *S. humeralis* (Curculionidae)	Limestone, stones, tiles
Solenopsis sp., *S. invicta* (Formicidae)	Ceramic tiles, tiles
Spermophagus sp., *S. sericeus* (Bruchidae)	Tiles
Spilosoma obliqua (Arctiidae)	Iron
Spilostethus sp., *S. pandurus* (Lygaeidae)	Tiles
Spodoptera littoralis (Noctuidae)	Tiles
Stagonomus pusillus (Pentatomidae)	Tiles
Stenodema sp. (Miridae)	Marble
Stephanitis pyri (Tingidae)	Limestone
Stephanopachys quadricollis (Bostrichidae)	Tiles
Stictopleurus crassicornis (Rhopalidae)	Marble, stones, tiles
Symphysa amoenalis (Crambidae)	Tiles
Systena sp. (Chrysomelidae)	Tiles
Taeniothrips sp. (Thripidae)	Stoneware
Taphropeltus contractus (Rhyparochromidae)	Tiles
Tephritis sp. (Tephritidae)	Tiles
Tetrix sp., *T. castaneum* (Tetrigidae)	Automobile parts, ceramic, electrical parts, granite, iron, limestone, machinery, marble, steel, tiles
Tetropium sp. (Cerambycidae)	Automobile parts, machinery, marble, stones, tiles
Tettigidea sp. (Tetrigidae)	Marble tiles
Tettigometra impressifrons (Tettigometridae)	Tiles
Tomarus sp. (Scarabaeidae)	Tiles
Tomicus sp., *T. minor*, *T. piniperda* (Curculionidae: Scolytinae)	Marble, tiles
Trichoferus sp. (Cerambycidae)	Machinery

Pest	Where intercepted
Trigonidium cicindeloides (Gryllidae)	Tiles
Trigonotylus sp. (Miridae)	Tiles
Trioza sp. (Psyllidae)	Tiles
Tropidothorax leucopterus (Lygaeidae)	Marble, tiles
Tropinota sp., *T. squalida* (Scarabaeidae)	Tiles
Trypodendron domesticum (Curculionidae: Scolytinae)	Tiles
Tychius sp. (Curculionidae)	Tiles
Utetheisa pulchella (Arctiidae)	Tiles
Xanthochilus saturnius, *X. quadratus* (Rhyparochromidae)	Container, limestone, marble, quarry product, tiles
Xerophloea sp. (Cicadellidae)	Tiles
Xestia sp. (Noctuidae)	Tiles
Xyleborus sp., *X. eurygraphus* (Curculionidae: Scolytinae)	Granite, marble, tiles
Xylocopa sp. (Xylocopidae)	Tiles
Xylothrips flavipes (Bostrichidae)	Machinery
Xylotrechus sp., *X. magnicollis*, *X. rusticus* (Cerambycidae)	Aluminum, machinery, marble, steel, tiles
Zabrotes sp. (Bruchidae)	Tiles
Zygaena sp., *Z. ephialtes* (Zygaenidae)	Marble, tiles
Mite	
Varroa destructor (Varroidae)	Container
Mollusk	
Achatina fulica (Achatinidae)	Tools
Agriolimax sp. (Agriolimacidae)	Tiles
Arion sp., *A. distinctus*, *A. vulgaris* (Arionidae)	Limestone, machinery, stones
Bradybaena sp. (Bradybaeinidae)	Iron, tiles, container, tires
Calcisuccinea sp., *C. luteola* (Succineidae)	Container

Pest	Where intercepted
Candidula sp., *C. intersecta*, *C. unifasciata* (Hygromiidae)	Container, limestone, marble, quarry product, stones, tiles, tractor
Cantareus apertus (Helicidae)	Tiles
Cathaica fasciola (Bradybaenidae)	Quarry product, tiles, machinery, container
Caucasotachea sp. (Helicidae)	Tiles
Cepaea sp. (Helicidae)	Tiles
Cernuella sp., *C. cisalpina*, *C. neglecta*, *C. virgata* (Hygromiidae)	Agricultural implements, bricks, boat, container, granite, limestone, machinery, marble, quarry products, ship holds, stoneware, tiles
Cochlicella sp., *C. acuta*, *C. conoidea* (Cochlicellidae)	Container, machinery, tiles
Cornu aspersum (Helicidae)	Stoneware, tiles, ceramic tiles, automobile parts, marble, ship stores
Deroceras sp., *D. panormitanum* (Agriolimacidae)	Tiles, containers
Eobania vermiculata (Helicidae)	Tiles, ceramic tiles, ship stores
Euhadra sp. (Bradybaenidae)	Tractor
Fruticocola fruticum (Bradybaenidae)	Tiles
Granodomus lima (Pleurodontidae)	Container, metal, scrap metal
Helicopsis sp. (Hygromiidae)	Container
Helix sp., *H. cincta*, *H. lucorum* (Helicidiae)	Container, quarry product, tiles
Hygromia cinctella (Hygromiidae)	Ceramic tiles, quarry product, tiles
Lehmannia sp., *L. valentiana* (Limacidae)	Container, granite, machinery, marble, metal, quarry product, steel, tiles
Limacus sp., *L. maculatus* (Limacidae)	Tiles
Limax sp., *L. cinereoniger* (Limacidae)	Tiles
Meghimatium bilineatum (Philomycidae)	Granite
Microxeromagna armillata (Hygromiidae)	Container, limestone, marble, stones, tiles
Milax nigricans (Milacidae)	Tiles
Monacha sp., *M. bincinctae*, *M. cantiana*, *M. cartusiana*, *M. obstructa*, *M. parumcincta*, *M. syriaca* (Hygromiidae)	Automobile parts, ceramic tiles, container, marble, quarry product, stoneware, tiles
Monachoides incarnatus (Hygromiidae)	Tiles
Otala sp., *O. punctata* (Helicidae)	Container, marble tiles, tiles
Oxychilus sp. (Oxychilidae)	Marble, tiles
Prietocella barbara (Cochlicellidae)	Container, marble, quarry product, tiles
Succinea sp. (Succineidae)	Container, quarry product

Pest	Where intercepted
Theba pisana (Helicidae)	Aluminum, automobile, ceramic tiles, container, limestone, marble, quarry product, stones, stoneware, tiles
Trochoidea sp., *T. elegans*, *T. pyramidata*, *T. trochoides* (Hygromiidae)	Container, limestone, quarry product, tiles
Xerolenta obvia (Hygromiidae)	Container, tiles
Xeropicta sp., *X. derbentina*, *X. krynickii*, *X. protea*, *X. vestalis* (Hygromiidae)	Container, limestone, marble, tiles
Xerosecta sp., *X. cespinum* (Hygromiidae)	Container, tiles
Xerotricha apicina, *X. conspurcata* (Hygromiidae)	Bricks, ceramic tiles, container, granite, machinery, marble, quarry product, ship stores, slate, stones, stoneware, tiles, tools
Zachrysia sp. (Pleurodontidae)	Container
Nematode	
Meloidogyne sp. (Meloidogynidae)	Tiles
Xiphinema sp. (Longidoridae)	Machinery
Weed	
Avena sp., *A. sterilis* (Poaceae)	Quarry product, Tiles, Stones
Imperata cylindrica (Poaceae)	Automobile, granite, iron, machinery, metal, quarry product, slate, tiles, tires
Ischaemum rugosum (Poaceae)	Tiles

Pest	Where intercepted
Oryza sp. (red rice) (Poaceae)	Ship holds, steel, tiles, tractor
Pennisetum polystachion (Poaceae)	Ceramic, marble, quarry product
Saccharum sp., *S. spontaneum* (Poaceae)	Granite, marble
Tridax procumbens (Asteraceae)	Ceramic, container, electrical parts, military vehicles

Table 5.4 Number of maritime vessels arriving at sea ports in the Greater Caribbean Region. Data is for 2006 unless otherwise noted.

Country or territory	Total vessels	Container vessels	Reference	Comments
Insular Caribbean				
Aruba	216	216	(Aruba Ports Authority, 2008)	Data for 2003.
Cayman Islands	155		(Cayman Islands Port Authority, 2008)	
Curaçao	2,684		(Curaçao Ports Authority, 2008)	Of the vessels arriving, 1,304 were designated as freighters.
Dominican Republic	3,656		(República Dominicana Oficina Nacional de Estadística, 2004)	Data for 2004. Of the vessels arriving, 2,617 were designated as freighters.
Guadeloupe	1,510		(Port of Guadeloupe, 2008)	Data for 2003. Only freight ships were reported.
Jamaica	2,755	2,004	(Port Authority of Jamaica, 2007)	
St. Lucia	938	382	(SLASPA, 2007)	
U.S. Virgin Islands	3,502		(U.S. Virgin Islands Port Authority, 2008)	Data for 2005 which includes vessels over 100 gross tons. It is assumed these are cargo vessels.
Central America				
Belize	199		(Port of Belize, 2008)	Includes bulk cargo vessels.
Costa Rica	3,042	1,036	(COCATRAM, 2007)	
El Salvador	718	281	(COCATRAM, 2007)	
Guatemala	3,366	1,479	(COCATRAM, 2007)	
Honduras	2,377	1,023	(COCATRAM, 2007)	
Nicaragua	621	151	(COCATRAM, 2007)	
Panama	6,159	3,967	(COCATRAM, 2007)	
United States				
Alabama	859		(Alabama State Port Authority, 2008)	Data from 2007.
Florida	8,502		(Jacksonville Port Authority, 2008, Port Everglades, 2008, Port of Miami-Dade, 2008, Port of Palm Beach, 2008)	Other ports in Florida may receive cargo vessels but are not reflected in this number.
Louisiana	2,000		(Port of New Orleans, 2008)	The number of vessels is the estimated average to arrive annually.
Mississippi	216		(Mississippi State Port Authority, 2008)	
Texas	7,548		(Port of Houston, 2008)	

Table 5.5 Container traffic and estimated number of containers with hitchhiker pests at ports of entry in the Greater Caribbean Region.

[1] Most ports reported only number of TEUs, not number of containers. However, data from several ports that specified container type allowed us to estimate a 80:20 ratio of forty-foot to twenty-foot containers. We used this ratio to estimate the number of containers based on reported number of TEUs for all remaining ports.

[2] The number of TEUs reported by ports often includes both containers entering and containers exiting the port. For ports that did not specify the direction of traffic flow, the estimated number of containers was divided by 2 to estimate the number of containers entering.

[3] Estimated based on a 0.234 container contamination rate provided by Gadgil *et al.* (2000).

Country	Port	Reported number of TEUs	Estimated number of containers [1]	Estimated number of containers entering [2]	Estimated number ofcontainers entering with plant pests [3]	Comments	Reference
Anguilla	**Not specified**	20,299	12,179	6,090	1,425	The number of TEUs and containers entering is estimated from 2001 data.	(Veenstra *et al.*, 2005)
Antigua and Barbuda	**Not specified**	35,000	21,000	10,500	2,457	The number of TEUs and containers entering is estimated from 2001 data.	(Veenstra *et al.*, 2005)
Aruba	**Oranjestad**	--	17,659	8,830	2,066	The number of containers is the total traffic volume in 2006. The number of containers entering is an estimate.	(Aruba Ports Authority, 2008)
Bahamas	**Freeport (Container Terminal)**	1,385,860	831,516	415,758	97,287	The number of TEUs is the total traffic volume in 2006. The number of containers entering is an estimate.	(Degerlund, 2007)
Barbados	**Bridgetown**	92,507	55,504	27,752	6,494	The number of TEUs is the total traffic volume in 2006. The number of containers entering is an estimate.	(Degerlund, 2007)

Country	Port	Reported number of TEUs	Estimated number of containers [1]	Estimated number of containers entering [2]	Estimated number ofcontainers entering with plant pests [3]	Comments	Reference
Belize	**Belize City**	37,527	24,516	12,258	2,868	The number of TEUs is the total traffic volume in 2006. The number of containers entering is an estimate.	(Port of Belize, 2008)
British Virgin Islands	**Not specified**	40,599	24,359	12,180	2,850	The number of TEUs and containers entering is estimated from 2001 data.	(Veenstra *et al.*, 2005)
Cayman Islands	**Georgetown**	30,003	18,002	18,002	4,212	The number of TEUs is the number entering in 2006. The number of containers is estimated.	(Cayman Islands Port Authority, 2008)
Colombia	**Not specified**	1,073,081	643,849	321,925	75,330	The number of TEUs is the total traffic volume in 2004. The number of containers entering is an estimate.	(UNCTAD, 2005, 2006)
Colombia	**Cartagena**	510,000	306,000	153,000	35,802	The number of TEUs is the total traffic volume in 2003. The number of containers entering is an estimate.	(UNCTAD, 2005)
Colombia Combined Total		*1,583,081*	*949,849*	*474,925*	*111,132*		
Costa Rica	**Caldera**	59,879	35,927	35,927	8,407	The number of TEUs is the number entering in 2006. The number of containers is estimated.	(COCATRAM, 2007)
Costa Rica	**Limón-Moín**	382,908	229,745	382,908	89,600	The number of TEUs is the number entering in 2006. The number of containers is estimated.	(COCATRAM, 2007)
Costa Rica Combined Total		*442,787*	*265,672*	*418,835*	*98,007*		

Country	Port	Reported number of TEUs	Estimated number of containers [1]	Estimated number of containers entering [2]	Estimated number ofcontainers entering with plant pests [3]	Comments	Reference
Cuba	**Havana**	317,105	190,263	95,132	22,261	The number of TEUs is the total traffic volume in 2005. The number of containers entering is an estimate.	(Degerlund, 2007)
Curaçao	**Not specified**	46,064	27,638	27,638	6,467	The number of TEUs is the number entering in 2006. The number of containers is estimated.	(Curaçao Ports Authority, 2008)
Dominica	**Roseau**	11,097	6,658	3,329	779	The number of TEUs is the total traffic volume in 2006. The number of containers entering is an estimate.	(Degerlund, 2007)
Dominican Republic	**La Romana**	1,397	838	419	98	The number of TEUs is the total traffic volume in 2005. The number of containers entering is an estimate.	(CEPAL, 2007)
Dominican Republic	**Rio Haina**	268,738	161,243	80,622	18,865	The number of TEUs is the total traffic volume in 2005. The number of containers entering is an estimate.	(CEPAL, 2007)
Dominican Republic	**Puerto Plata**	47,119	28,271	14,136	3,308	The number of TEUs is the total traffic volume in 2005. The number of containers entering is an estimate.	(CEPAL, 2007)
Dominican Republic	**Santo Domingo**	11,244	6,746	3,373	789	The number of TEUs is the total traffic volume in 2005. The number of containers entering is an estimate.	(CEPAL, 2007)
Dominican Republic	**Boca Chica**	26,906	16,144	8,072	1,889	The number of TEUs is the total traffic volume in 2005. The number of containers entering is an estimate.	(CEPAL, 2007)

Country	Port	Reported number of TEUs	Estimated number of containers [1]	Estimated number of containers entering [2]	Estimated number ofcontainers entering with plant pests [3]	Comments	Reference
Dominican Republic	**Manzanillo**	1,622	973	487	114	The number of TEUs is the total traffic volume in 2005. The number of containers entering is an estimate.	(CEPAL, 2007)
Dominican Republic Combined Total		*357,026*	*214,215*	*107,109*	*25,063*		
El Salvador	**Acajutla**	65,722	39,433	39,433	9,227	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(COCATRAM, 2007)
Guatemala	**Santo Tomas de Castilla**	169,258	101,555	101,555	23,764	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(COCATRAM, 2007)
Guatemala	**Barrios**	107,124	64,274	64,274	15,040	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(COCATRAM, 2007)
Guatemala	**Quetzal**	102,633	61,580	61,580	14,410	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(COCATRAM, 2007)
Guatemala Combined Total		*379,015*	*227,409*	*227,409*	*53,214*		
Guadeloupe	**Not specified**	77,158	46,295	46,295	10,833	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(Port of Guadeloupe, 2008)
Guadeloupe	**Basse-Terre**	2,274	1,364	682	160	The number of TEUs is the total traffic volume in 2004. The number of containers is an estimate.	(Port of Guadeloupe, 2008)

Country	Port	Reported number of TEUs	Estimated number of containers [1]	Estimated number of containers entering [2]	Estimated number ofcontainers entering with plant pests [3]	Comments	Reference
Guadeloupe	**Jarry/ Pointe-a-Pitre**	154,263	92,558	46,279	10,829	The number of TEUs is the total traffic volume in 2005. The number of containers entering is an estimate.	(CEPAL, 2007)
Guadeloupe Combined Total		*231,421*	*138,853*	*92,574*	*21,662*		
Guyana	**Not specified**	13,398	8,039	4,020	941	The number of TEUs and containers entering is estimated from 2001 data.	(Veenstra *et al.*, 2005)
Haiti	**Not specified**	555,489	333,293	166,647	38,995	The number of TEUs is the total traffic volume in 2004. The number of containers entering is an estimate.	(UNCTAD, 2005, 2006)
Honduras	**Cortés**	253,520	152,112	152,112	35,594	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(COCATRAM, 2007)
Honduras	**Castilla**	40,590	24,354	24,354	5,699	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(COCATRAM, 2007)
Honduras	**San Lorenzo**	106	64	32	7	The number of TEUs is the total traffic volume in 2005. The number of containers entering is an estimate.	(CEPAL, 2007)
Honduras Combined Total		*294,216*	*176,530*	*176,498*	*41,300*		
Jamaica	**Kingston**	1,670,800	1,002,000	501,000	117,234	The number of TEUs is the total traffic volume in 2005. The number of containers entering is an estimate.	(Degerlund, 2007)

Country	Port	Reported number of TEUs	Estimated number of containers [1]	Estimated number of containers entering [2]	Estimated number ofcontainers entering with plant pests [3]	Comments	Reference
Jamaica	**other outports**	142,110	85,266	42,633	9,976	The number of TEUs is the total traffic volume in 2003. The number of containers entering is an estimate.	(UNCTAD, 2005)
Jamaica Combined Total		*1,812,910*	*1,087,266*	*543,633*	*127,210*		
Martinique	**Not specified**	143,877	86,266	43,133	10,093	The number of TEUs and containers entering is estimated from 2001 data.	(Veenstra *et al.*, 2005)
Netherland Antilles	**Not specified**	1,605,074	963,044	481,522	112,676	The number of TEUs is the total traffic volume in 2003. The number of containers entering is an estimate.	(UNCTAD, 2005)
Nicaragua	**Arlen Siu**	795	477	477	112	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(COCATRAM, 2007)
Nicaragua	**Corinto**	24,205	14,523	14,523	3,398	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(COCATRAM, 2007)
Nicaragua	**El Bluff**	121	73	73	17	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(COCATRAM, 2007)
Nicaragua Combined Total		*25,121*	*15,073*	*15,073*	*3,527*		
Panama	**Almirante**	4,242	2,425	2,425	567	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(COCATRAM, 2007)
Panama	**Balboa**	504,349	302,610	302,610	70,811	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(COCATRAM, 2007)

Country	Port	Reported number of TEUs	Estimated number of containers [1]	Estimated number of containers entering [2]	Estimated number ofcontainers entering with plant pests [3]	Comments	Reference
Panama	**Chiriqui Grande Terminal**	2,606	1,303	652	66	The number of containers entering in 2006 is the actual number reported.	(COCATRAM, 2007)
Panama	**Colon, includes Manzanillo, Evergreen, Panama Port**	729,165	437,499	437,499	102,375	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(COCATRAM, 2007)
Panama	**Colon Container Terminal**	812	487	487	114	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(COCATRAM, 2007)
Panama	**Cristobal**	80,799	46,554	23,277	5,447	The number of containers is the total container traffic volume in 2006; the number of containers entering is an estimate.	(COCATRAM, 2007)
Panama	**Manzanillo International Terminal**	1,331,267	788,324	394,162	92,234	The number of containers entering is the actual number reported in 2006.	(COCATRAM, 2007)

Country	Port	Reported number of TEUs	Estimated number of containers [1]	Estimated number of containers entering [2]	Estimated number ofcontainers entering with plant pests [3]	Comments	Reference
Panama	**Panama Ports Company**	49,133	29,480	29,480	6,898	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(COCATRAM, 2007)
Panama Combined Total		*2,702,373*	*1,608,682*	*1,190,592*	*278,512*		
Puerto Rico	**San Juan**	1,727,389	1,036,433	518,217	121,263	The number of TEUs is the total traffic volume in 2005. The number of containers entering is an estimate.	(Degerlund, 2007)
St. Kitts and Nevis	**Not specified**	40,599	24,359	12,180	2,850	The number of TEUs and containers entering is estimated from 2001 data.	(Veenstra *et al.*, 2005)
St Lucia	**Port Castries**	16,544	9,926	9,926	2,323	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(SLASPA, 2007)
St. Lucia	**Port Vieux-Fort**	4,070	2,442	2,442	571	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(SLASPA, 2007)
St. Lucia Combined Total		*20,614*	*12,368*	*12,368*	*2,894*		
St. Martin	**Not specified**	440,368	264,221	132,111	30,914	The number of TEUs is the total traffic volume in 2003. The number of containers entering is an estimate.	(UNCTAD, 2005)
St. Vincent and the Grenadines	**Not specified**	40,599	24,359	12,180	2,850	The number of TEUs and containers entering is estimated from 2001 data.	(Veenstra *et al.*, 2005)
Suriname	**Paramaribo**	25,374	15,224	7,612	1,781	The number of TEUs and containers entering is estimated from 2001 data.	(Veenstra *et al.*, 2005)

Country	Port	Reported number of TEUs	Estimated number of containers [1]	Estimated number of containers entering [2]	Estimated number ofcontainers entering with plant pests [3]	Comments	Reference
Trinidad and Tobago	**Port-of-Spain**	322,466	193,480	96,740	22,637	The number of TEUs is the total traffic volume in 2005. The number of containers entering is an estimate.	(CEPAL, 2007)
Trinidad and Tobago	**Port Point Lisas**	99,000	59,400	29,700	6,950	The number of TEUs is the total traffic volume in 2004. The number of containers entering is an estimate.	(CEPAL, 2007)
Trinidad and Tobago Combined Total		*421,466*	*252,880*	*126,440*	*29,587*		
U.S. Virgin Islands	**Not specified**	37,643	22,586	11,293	2,643	The number of TEUs and containers entering is estimated from 2001 data.	(Veenstra *et al.*, 2005)
U.S. – Alabama	**Not specified**	108,572	65,143	32,572	7,622	The number of TEUs is the total traffic volume in 2006. The number of containers entering is an estimate.	(Alabama State Port Authority, 2008)
U.S. - Florida	**Miami**	976,514	585,908	292,954	68,551	The number of TEUs is the total traffic volume in 2006. The number of containers entering is an estimate.	(Port of Miami-Dade, 2008)
U.S. - Florida	**Jacksonville**	768,239	153,648	76,824	17,977	The number of TEUs is the total traffic volume in 2006. The number of containers entering is an estimate.	(Jacksonville Port Authority, 2008)
U.S. - Florida	**Palm Beach**	116,380	69,828	69,828	16,340	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(Port of Palm Beach, 2008)

Country	Port	Reported number of TEUs	Estimated number of containers [1]	Estimated number of containers entering [2]	Estimated number ofcontainers entering with plant pests [3]	Comments	Reference
U.S. - Florida	**Port Everglades**	239,506	143,704	143,704	33,627	The number of TEUs is the number entering in 2006. The number of containers is an estimate.	(Port Everglades, 2008)
U.S. – Louisiana	**Port of New Orleans**	300,000	180,000	90,000	21,060	The number of TEUs is the total number entering in 2005. The number of containers entering is an estimate.	(Degerlund, 2007)
U.S. – Mississippi	**Port of Gulfport**	48,751	48,751	48,751	11,408	The number of containers is the actual number entering in 2006.	(Mississippi State Port Authority, 2008)
U.S. – Texas	**Port of Houston Authority**	1,582,081	949,249	474,624	111,062	The number of TEUs is the total traffic volume in 2005. The number of containers entering is an estimate.	(Degerlund, 2007)
U.S. – Texas	**Port of San Antonio**	773,048	463,829	231,914	54,268	The number of TEUs arriving in 2005 is the total number entering. The number of containers is estimated.	(Degerlund, 2007)
U.S. Gulf States Combined Total		*4,913,091*	*2,660,060*	*1,461,171*	*341,915*		
Greater Caribbean Region Total			11,655,408	6,913,124	1,617,581		

Figure 6.1 Percentage (and 95% binomial confidence interval) of maritime cargo (both agricultural and non-agricultural) imported into the United States with wood packaging material (Data source: (USDA, 2008f), Sept. 16, 2005-Aug. 15, 2007).

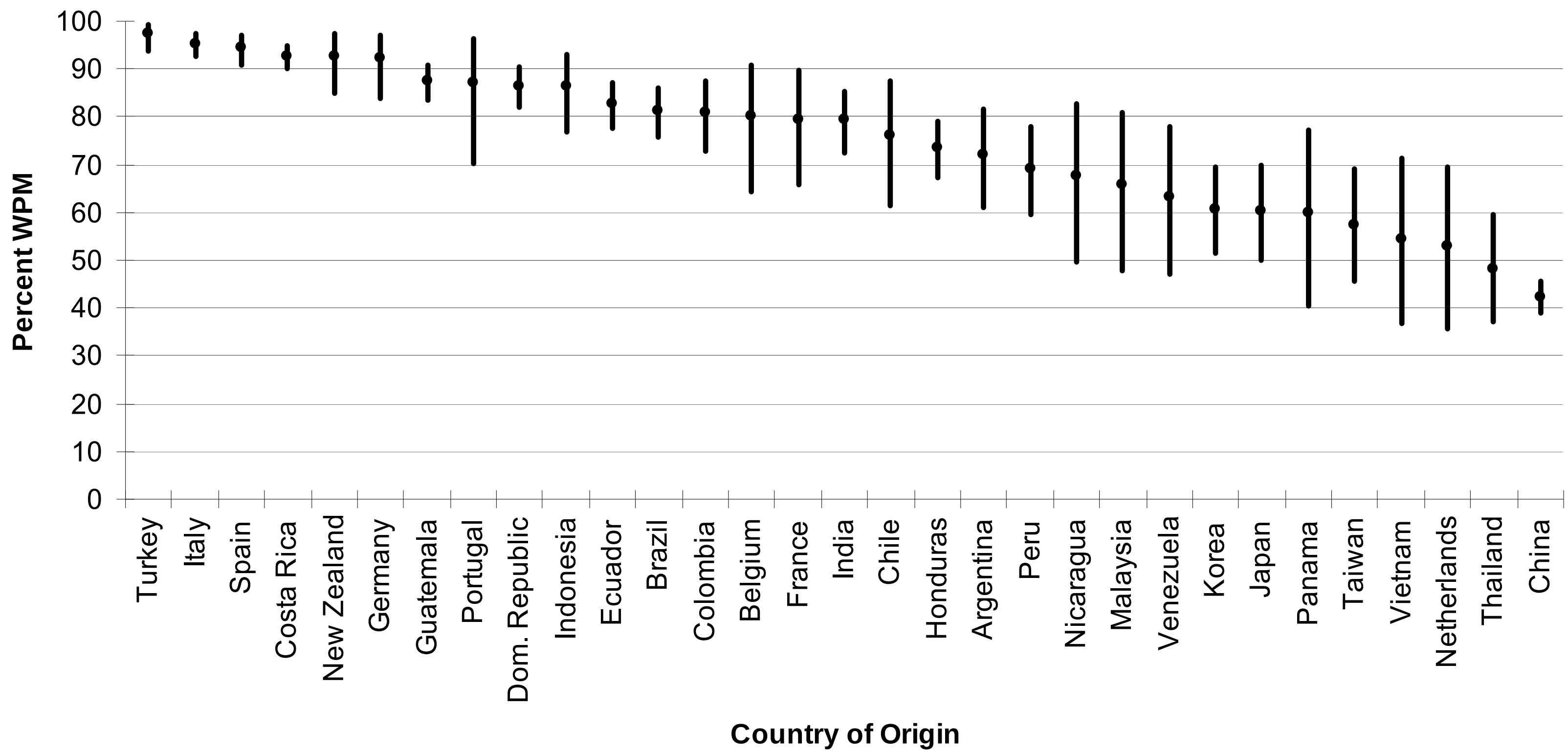


Figure 6.2 Percentage (and 95% binomial confidence interval) of maritime agricultural cargo with wood packaging material imported into the United States between September 16, 2005 - August 15, 2007. Data source: (USDA, 2008f).

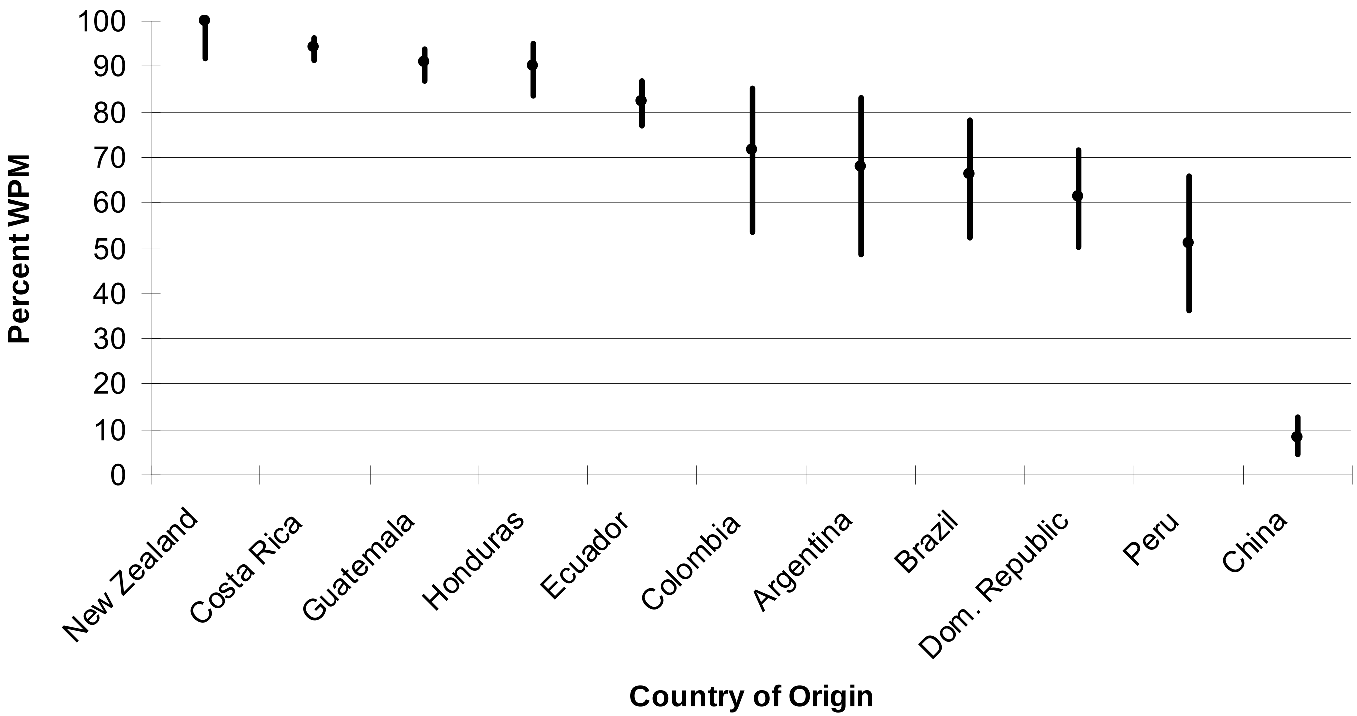


Figure 6.3 Percentage (and 95% binomial confidence interval) of maritime non-agricultural cargo with wood packaging material imported into the United States between September 16, 2005 - August 15, 2007. Data source: (USDA, 2008f).

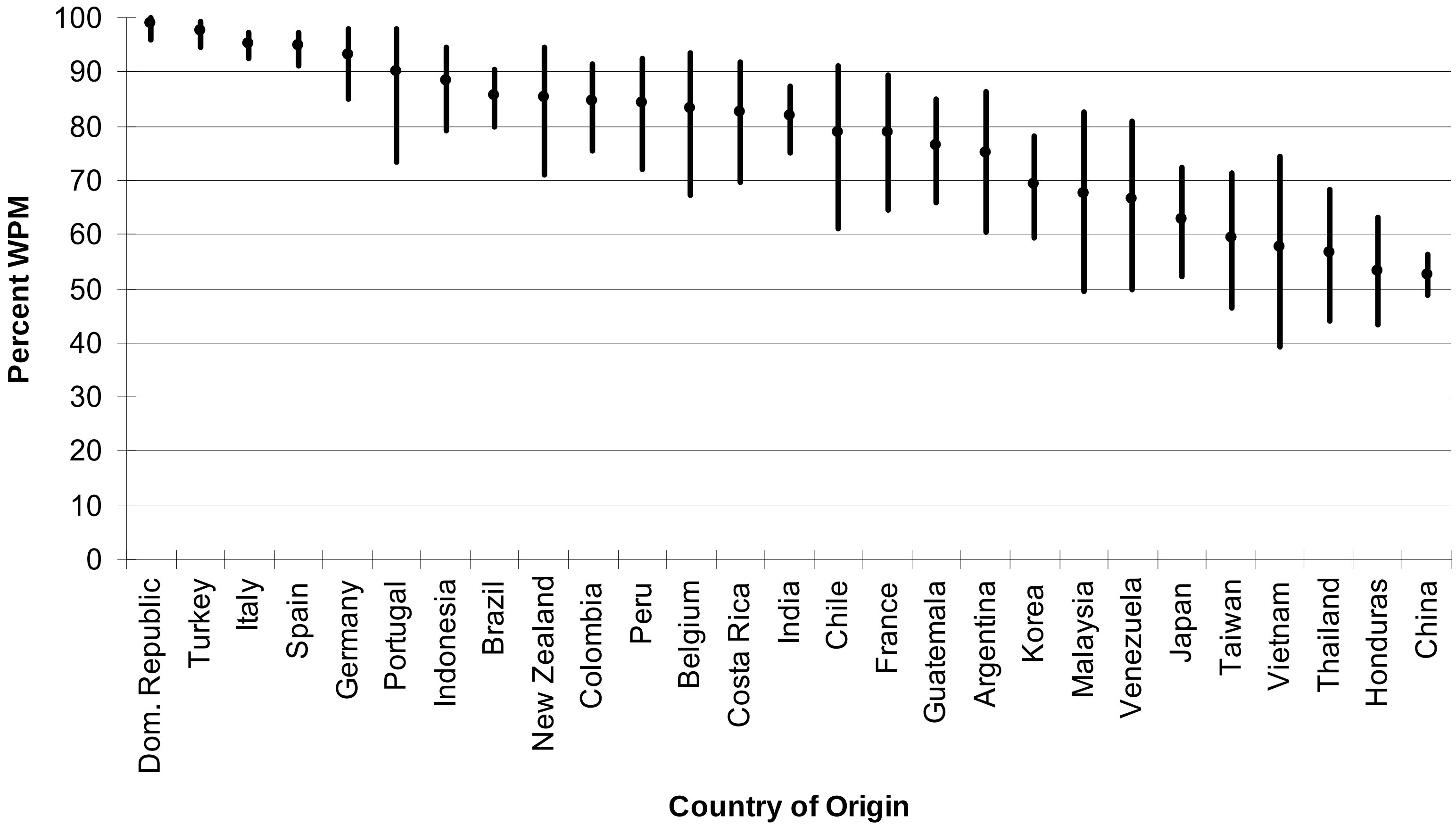


Figure 6.4 Percentage (and 95% binomial confidence interval) of agricultural air cargo with wood packaging material imported into the United States between September 16, 2005 – August 15, 2007. Data source: (USDA, 2008f).

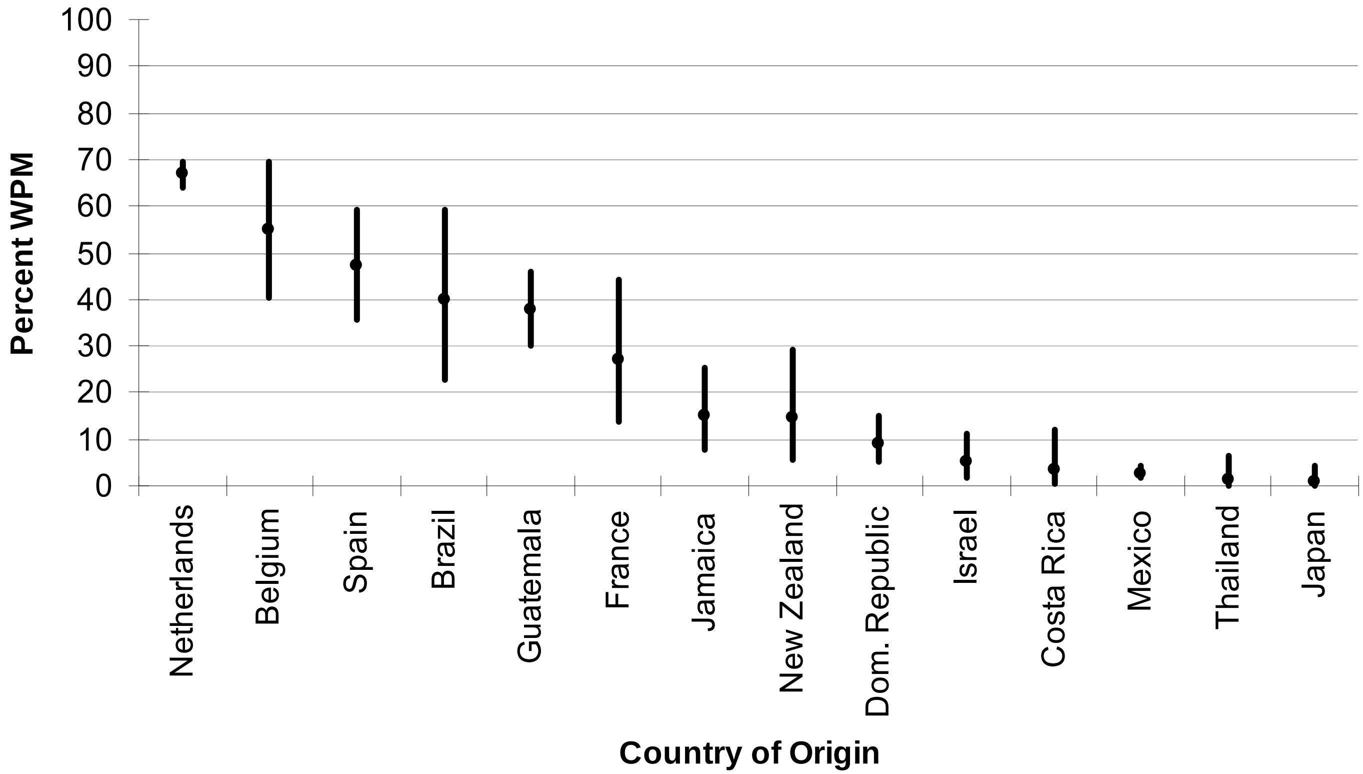


Table 6.1 Imports of wood packaging material into Caribbean Region (2006) (Data source: (UNComtrade, 2008)).

	Exporting countries				
	Caribbean Islands	Central America	Guyana/ Suriname	USA[1]	World
Importing countries	(metric tonnes)				
Caribbean Islands	230.0	--	--	1,766.9	2,481.4
Central America	0.2	10,244.1	1.4	3,127.5	14,724.0
Guyana/Suriname	--	--	--	1.3	5.2

[1] Includes all of United States

Table 6.2 Exports of wood packaging material from Caribbean Region (2006) (Data source: (UNComtrade, 2008)).

	Importing countries				
	Greater Antilles	Central America	Guyana/ Suriname	USA[1]	World
Exportng countries	(metric tonnes)				
Caribbean Islands	72.5	4.2	--	254.3	332.4
Central America	0.1	7,652.5	--	18,871.2	29,574.3
Guyana/Suriname	--	--	--	0.01	0.7

[1] Includes all of United States

Table 6.3 Pest taxa (not necessarily of U.S. quarantine significance) intercepted on or in wood material at U.S. ports of entry between July 5, 2006 and January 1, 2008 (Data source: (USDA, 2008d)).

Order	Family	Interceptions	Specimens
Coleoptera	Anobiidae	2	2
	Bostrichidae	9	32
	Buprestidae	15	16
	Cerambycidae	38	49
	Chrysomelidae	1	3
	Cleridae	3	17
	Corticariidae	1	5
	Cryptophagidae	3	3
	Curculionidae	40	131
	Curculionidae: Scolytinae	247	788
	Histeridae	1	1
	Laemophloeidae	1	1
	Mycetophagidae	1	1
	Nitidulidae	2	8
	Platypodidae	8	13
	Scarabaeidae	2	2
	Silvanidae	5	13
	Staphylinidae	1	1
	Tenebrionidae	2	3
Diptera	Scatopsidae	1	4
Hemiptera	Aradidae	1	1
	Cixiidae	1	1
	Coreidae	1	1
	Miridae	1	1
	Reduviidae	1	1
	Rhyparochromidae	1	1
Hymenoptera	Apidae	1	1
	Formicidae	8	78
Isopoda	unknown	1	3
Isoptera	Rhinotermitidae	4	135
	Termitidae	1	4
Lepidoptera	Geometridae	2	2
	Pyralidae	3	4
	Tineidae	1	1
Mollusks	Cochlicellidae	1	3
	Helicidae	2	12
Orthoptera	Gryllidae	2	2
	Tettigoniidae	1	2
Plant	Asteraceae	1	.
	Boraginaceae	1	.
	Poaceae	4	.
	Ulmaceae	1	.
TOTAL		**424**	**1,346**

Table 6.4 Species intercepted at U.S. ports of entry on or in wood material between January of 1985 and May of 2007. (This list is not comprehensive.) (Data source: (USDA, 2008d))

Pest	Family
Pathogens	
Apiospora montagnei	Apiosporaceae
Ascochyta sp.	Family of Coelomycetes
Aspergillus sp.	Family of Hyphomycetes
Cladosporium sp.	Family of Hyphomycetes
Colletotrichum gloeosporioides	Family of Coelomycetes
Cytospora sp.	Family of Coelomycetes
Didymella sp.	Pleosporaceae
Eurotium sp.	
Graphiola sp.	Graphiolaceae
Gymnosporangium sp.	Pucciniaceae
Hemisphaeriales, species	
Lasiodiplodia theobromae	Family of Coelomycetes
Lichen sp.	
Lophodermium sp.	Rhytismataceae
Melanomma sp.	
Mycosphaerella sp.	Mycosphaerellaceae
Mycospharella fijiensis	
Pestalotiopsis sp.	Family of Coelomycetes
Phoma sp.	Family of Coelomycetes
Phomopsis sp.	Family of Coelomycetes
Polyporus versicolor	Polyporaceae
Puccinia sp.	Pucciniaceae
Rhizoctonia solani	
Saprophyte sp.	
Insects	
Acalles sp.	Curculionidae
Acalymma vittatum	Chrysomelidae
Acanthocephala femorata	Coreidae
Acanthocephala sp.	Coreidae
Acanthocinus aedilis	Cerambycidae

Pest	Family
Acanthocinus griseus	Cerambycidae
Acanthocinus sp.	Cerambycidae
Acanthoscelides sp.	Bruchidae
Acheta domesticus	Gryllidae
Acheta hispanicus	Gryllidae
Acheta sp.	Gryllidae
Acmaeodera sp.	Buprestidae
Acrididae, species	
Acroleucus bromelicola	Lygaeidae
Acrolophus sp.	Acrolophidae
Acrosternum millierei	Pentatomidae
Acyphoderes sp.	Cerambycidae
Adelina plana	Tenebrionidae
Adelina sp.	Tenebrionidae
Adelphocoris lineolatus	Miridae
Adoretus sinicus	Scarabaeidae
Aelia acuminata	Pentatomidae
Aelia sp.	Pentatomidae
Aeolesthes sp.	Cerambycidae
Aeolus sp.	Elateridae
Aethus indicus	Cydnidae
Agallia laevis	Cicadellidae
Agallia sp.	Cicadellidae
Agapanthia irrorata	Cerambycidae
Aglossa caprealis	Pyralidae
Agrilus sp.	Buprestidae
Agrilus sulcicollis	Buprestidae
Agriotes aequalis	Elateridae
Agriotes lineatus	Elateridae
Agriotes sp.	Elateridae
Agromyzidae, species	
Agrotis exclamationis	Noctuidae
Agrotis ipsilon	Noctuidae
Agrotis sp.	Noctuidae
Agrypninae, species	Elateridae
Ahasverus advena	Silvanidae
Ahasverus sp.	Silvanidae
Alaus oculatus	Elateridae
Alaus sp.	Elateridae
Alphitobius diaperinus	Tenebrionidae
Alphitobius laevigatus	Tenebrionidae
Altica oleracea	Chrysomelidae
Altica sp.	Chrysomelidae

Pest	Family
Alydus pilosulus	Alydidae
Alydus sp.	Alydidae
Amenophis sp.	Tenebrionidae
Ametastegia sp.	Tenthredinidae
Amitermes sp.	Termitidae
Amphiacusta azteca	Gryllidae
Amphicerus cornutus	Bostrichidae
Amphicerus sp.	Bostrichidae
Anaceratagallia venosa	Cicadellidae
Anacridium aegyptium	Acrididae
Anasa sp.	Coreidae
Anastrepha sp.	Tephritidae
Anelaphus moestus	Cerambycidae
Anelaphus sp.	Cerambycidae
Anobiidae, species	
Anobium punctatum	Anobiidae
Anomala sp.	Scarabaeidae
Anoplophora glabripennis	Cerambycidae
Anoplophora sp.	Cerambycidae
Anthaxia sp.	Buprestidae
Anthicidae, species	
Anthocoridae, species	
Anthomyiidae, species	
Anthonomus eugenii	Curculionidae
Anthonomus sp.	Curculionidae
Araptus sp.	Curculionidae: Scolytinae
Anthrenus sp.	Dermestidae
Anthribidae, species	
Anticarsia irrorata	Noctuidae
Anurogryllus sp.	Gryllidae
Apate sp.	Bostrichidae
Aphanus rolandri	Rhyparochromidae
Aphididae, species	
Aphodiinae, species	Scarabaeidae
Aphorista sp.	Endomychidae
Aphthona sp.	Chrysomelidae
Apidae, species	
Apion sp.	Apionidae
Apionidae, species	
Apis mellifera	Apidae
Apis sp.	Apidae
Apocrita, species	

Pest	Family
Apriona sp.	Cerambycidae
Aradidae, species	
Aradus betulae	Aradidae
Aradus sp.	Aradidae
Araecerus sp.	Anthribidae
Archipini, species	Tortricidae
Arctiidae, species	
Arhopalus asperatus	Cerambycidae
Arhopalus ferus	Cerambycidae
Arhopalus rusticus	Cerambycidae
Arhopalus sp.	Cerambycidae
Arhopalus syriacus	Cerambycidae
Aridius sp.	Lathridiidae
Arma custos	Pentatomidae
Arocatus longiceps	Lygaeidae
Arocatus melanocephalus	Lygaeidae
Arocatus roeselii	Lygaeidae
Aromia moschata	Cerambycidae
Ascalapha odorata	Noctuidae
Aseminae, species	Cerambycidae
Asemum sp.	Cerambycidae
Asemum striatum	Cerambycidae
Asilidae, species	
Aspidiella hartii	Diaspididae
Aspidomorpha sp.	Chrysomelidae
Asynapta sp.	Cecidomyiidae
Ataenius sp.	Scarabaeidae
Atractomorpha sp.	Pyrgomorphidae
Atrazonatus umbrosus	Lygaeidae
Atta sp.	Formicidae
Attagenus sp.	Dermestidae
Auchenorrhyncha, species	
Aulacaspis tubercularis	Diaspididae
Aulacophora sp.	Chrysomelidae
Aulacorthum solani	Aphididae
Aulonsoma sp.	Passandridae
Autographa californica	Noctuidae
Autographa gamma	Noctuidae
Azteca sp.	Formicidae
Bactrocera dorsalis	Tephritidae
Bactrocera sp.	Tephritidae
Baridinae, species	Curculionidae
Baris sp.	Curculionidae

Pest	Family
Batocera rufomaculata	Cerambycidae
Batocera sp.	Cerambycidae
Belionota prasina	Buprestidae
Belionota sp.	Buprestidae
Beosus maritimus	Rhyparochromidae
Beosus quadripunctatus	Rhyparochromidae
Beosus sp.	Rhyparochromidae
Bethylidae, species	
Biphyllidae, species	
Blapstinus sp.	Tenebrionidae
Blastobasinae, species	Coleophoridae
Blattidae, species	
Blissus insularis	Blissidae
Blissus sp.	Blissidae
Bostrichidae, species	
Bostrichinae, species	Bostrichidae
Bostrichini, species	Bostrichidae
Bostrychoplites cornutus	Bostrichidae
Brachmia sp.	Gelechiidae
Brachypeplus sp.	Nitidulidae
Braconidae, species	
Braconinae, species	Braconidae
Brentidae, species	
Brentus sp.	Brentidae
Brochymena parva	Pentatomidae
Brochymena quadripustulata	Pentatomidae
Brochymena sp.	Pentatomidae
Bruchidius sp.	Bruchidae
Bruchinae, species	Chrysomelidae
Bryothopha sp.	Gelechiidae
Bucrates capitatus	Tettigoniidae
Buprestidae, species	
Buprestis dalmatina	Buprestidae
Buprestis haemorrhoidalis	Buprestidae
Buprestis sp.	Buprestidae
Buprestis viridisuturalis	Buprestidae
Cacopsylla sp.	Psyllidae
Cadra cautella	Pyralidae
Cadra sp.	Pyralidae
Callidiellum rufipenne	Cerambycidae
Callidiellum sp.	Cerambycidae
Callidiellum villosulum	Cerambycidae
Callidium aeneum	Cerambycidae

Pest	Family
Callidium sp.	Cerambycidae
Callidium violaceum	Cerambycidae
Calligrapha sp.	Chrysomelidae
Calliphorinae, species	Calliphoridae
Callosobruchus sp.	Bruchidae
Camponotus fallax	Formicidae
Camponotus rufipes	Formicidae
Camponotus sp.	Formicidae
Camptomyia sp.	Cecidomyiidae
Camptopus lateralis	Alydidae
Camptorhinus sp.	Curculionidae
Cantharidae, species	
Carabidae, species	
Carphoborus bifurcus	Curculionidae: Scolytinae
Carphoborus minimus	Curculionidae: Scolytinae
Carphoborus pini	Curculionidae: Scolytinae
Carphoborus rossicus	Curculionidae: Scolytinae
Carphoborus sp.	Curculionidae: Scolytinae
Carpocoris pudicus	Pentatomidae
Carpophilus sp.	Nitidulidae
Cartodere constricta	Corticariidae
Carulaspis juniperi	Diaspididae
Caryedon sp.	Bruchidae
Cassidinae, species	Chrysomelidae
Cathartosilvanus opaculus	Silvanidae
Catocalinae, species	Noctuidae
Catolethrus sp.	Curculionidae
Catorhintha sp.	Coreidae
Caulotops sp.	Miridae
Cecidomyiidae, species	
Cecidomyiinae, species	Cecidomyiidae
Centrocoris spiniger	Coreidae
Centrocoris variegatus	Coreidae
Cerambycidae, species	
Cerambycinae, species	Cerambycidae
Cerambyx sp.	Cerambycidae
Ceraphronidae, species	
Ceratagallia sp.	Cicadellidae
Ceratitini, species	Tephritidae

Pest	Family
Ceratitis capitata	Tephritidae
Ceratopogonidae, species	
Cercopidae, species	
Ceresium sp.	Cerambycidae
Cerylonidae, species	
Ceutorhynchus sp.	Curculionidae
Chaetocnema concinna	Chrysomelidae
Chaetocnema conducta	Chrysomelidae
Chaetocnema sp.	Chrysomelidae
Chaetocnema tibialis	Chrysomelidae
Chaetophloeus mexicanus	Curculionidae: Scolytinae
Chalcidoidea, species	
Chalcoises plutus	Chrysomelidae
Chalcophora georgiana	Buprestidae
Chalcophora sp.	Buprestidae
Chalcophora virginiensis	Buprestidae
Cheirodes sp.	Tenebrionidae
Chilo sp.	Crambidae
Chilo suppressalis	Crambidae
Chironomidae, species	
Chlorida festiva	Cerambycidae
Chlorochroa senilis	Pentatomidae
Chlorophanus sp.	Curculionidae
Chlorophorus annularis	Cerambycidae
Chlorophorus diadema	Cerambycidae
Chlorophorus pilosus	Cerambycidae
Chlorophorus sp.	Cerambycidae
Chramesus sp.	Curculionidae: Scolytinae
Chrysauginae, species	Pyralidae
Chrysobothrini, species	Buprestidae
Chrysobothris chrysostigma	Buprestidae
Chrysobothris femorata	Buprestidae
Chrysobothris octocola	Buprestidae
Chrysobothris sp.	Buprestidae
Chrysodeixis chalcites	Noctuidae
Chrysolina bankii	Chrysomelidae
Chrysolina polita	Chrysomelidae
Chrysolina rossia	Chrysomelidae
Chrysolina sp.	Chrysomelidae
Chrysomela sp.	Chrysomelidae
Chrysomelidae, species	

Pest	Family
Cicadella viridis	Cicadellidae
Cicadellidae, species	
Ciidae, species	
Cinara sp.	Aphididae
Cixiidae, species	
Cleonis sp.	Curculionidae
Cleonus sp.	Curculionidae
Cleridae, species	
Clytini, species	Cerambycidae
Clytus sp.	Cerambycidae
Cnemonyx sp.	Curculionidae: Scolytinae
Cneorhinus sp.	Curculionidae
Coccinella septempunctata	Coccinellidae
Coccinella sp.	Coccinellidae
Coccinellidae, species	
Coccotrypes sp.	Curculionidae: Scolytinae
Coccus viridis	Coccidae
Colaspis sp.	Chrysomelidae
Coleophoridae, species	
Coleoptera, species	
Collembola, species	
Collops sp.	Melyridae
Colydiidae, species	
Colydiinae, species	Zopheridae
Conarthrus sp.	Curculionidae
Conchaspis newsteadi	Conchaspididae
Conistra rubiginea	Noctuidae
Conocephalus sp.	Tettigoniidae
Conoderus sp.	Elateridae
Conotrachelus sp.	Curculionidae
Copitarsia sp.	Noctuidae
Coptocycla sordida	Chrysomelidae
Coptops sp.	Cerambycidae
Coptotermes crassus	Rhinotermitidae
Coptotermes formosanus	Rhinotermitidae
Coptotermes sp.	Rhinotermitidae
Coptotermes testaceus	Rhinotermitidae
Corcyra cephalonica	Pyralidae
Coreidae, species	
Corimelaena pulicaria	Thyreocoridae
Corixidae, species	

Pest	Family
Corizus hyoscyami	Rhopalidae
Corticariidae, species	
Corticarina sp.	Corticariidae
Corticeus sp.	Tenebrionidae
Corylophidae, species	
Cossidae, species	
Cossoninae, species	Curculionidae
Cossonus sp.	Curculionidae
Cossus cossus	Cossidae
Crambidae, species	
Crambinae, species	Crambidae
Crematogaster scutellaris	Formicidae
Crematogaster sp.	Formicidae
Crocistethus waltlianus	Cydnidae
Cryphalus abietis	Curculionidae: Scolytinae
Cryphalus piceae	Curculionidae: Scolytinae
Cryphalus sp.	Curculionidae: Scolytinae
Cryptamorpha desjardinsii	Silvanidae
Cryptinae, species	Ichneumonidae
Cryptoblabes sp.	Pyralidae
Cryptolaemus montrouzieri	Coccinellidae
Cryptolestes sp.	Laemophloeidae
Cryptophagidae, species	
Cryptophagus sp.	Cryptophagidae
Cryptophilinae, species	Erotylidae
Cryptophilini, species	Erotylidae
Cryptophilus sp.	Erotylidae
Cryptophlebia leucotreta	Tortricidae
Cryptophlebia sp.	Tortricidae
Cryptorhynchinae, species	Curculionidae
Cryptorhynchus sp.	Curculionidae
Cryptotermes brevis	Kalotermitidae
Cryptotermes domesticus	Kalotermitidae
Cryptotermes sp.	Kalotermitidae
Crypturgus cinereus	Curculionidae: Scolytinae
Crypturgus mediterraneus	Curculionidae: Scolytinae
Crypturgus numidicus	Curculionidae: Scolytinae
Crypturgus pusillus	Curculionidae: Scolytinae

Pest	Family
Crypturgus sp.	Curculionidae: Scolytinae
Ctenuchinae, species	Arctiidae
Cucujidae, species	
Cucujoidea, species	
Culicidae, species	
Curculio sp.	Curculionidae
Curculionidae, species	
Curculionoidea, species	
Cyclocephala sp.	Scarabaeidae
Cyclocephalini, species	Scarabaeidae
Cycloneda polita	Coccinellidae
Cyclorrhapha, species	
Cydia sp.	Tortricidae
Cydnidae, species	
Cylindrocopturus sp.	Curculionidae
Cymatodera sp.	Cleridae
Cymatothes tristis	Tenebrionidae
Cynipidae, species	
Cyphostethus tristriatus	Acanthosomatidae
Cyrtogenius luteus	Curculionidae: Scolytinae
Cyrtogenius sp.	Curculionidae: Scolytinae
Dargida procincta	Noctuidae
Delia platura	Anthomyiidae
Delphacidae, species	
Deltocephalinae, species	Cicadellidae
Demonax sp.	Cerambycidae
Dendrobiella aspera	Bostrichidae
Dendrobiella sericans	Bostrichidae
Dendrocoris reticulatus	Pentatomidae
Dendrocoris sp.	Pentatomidae
Dendroctonus frontalis	Curculionidae: Scolytinae
Dendroctonus mexicanus	Curculionidae: Scolytinae
Dendroctonus pseudotsugae	Curculionidae: Scolytinae
Dendroctonus sp.	Curculionidae: Scolytinae
Dendroctonus valens	Curculionidae: Scolytinae
Deraeocoris punctulatus	Miridae
Deraeocoris sp.	Miridae

Pest	Family
Derbidae, species	
Dere thoracica	Cerambycidae
Dermaptera, species	
Dermestes maculatus	Dermestidae
Dermestes sp.	Dermestidae
Dermestidae, species	
Diabrotica sp.	Chrysomelidae
Diabrotica undecimpunctata	Chrysomelidae
Dialeurodes citri	Aleyrodidae
Diaspididae, species	
Dicerca lurida	Buprestidae
Dicerca sp.	Buprestidae
Dictyopharidae, species	
Diestrammena (tachycines)	Gryllacrididae
Dieuches armatipes	Rhyparochromidae
Dihammus sp.	Cerambycidae
Dinoderinae, species	Bostrichidae
Dinoderus bifoveolatus	Bostrichidae
Dinoderus brevis	Bostrichidae
Dinoderus minutus	Bostrichidae
Dinoderus sp.	Bostrichidae
Diorthus sp.	Cerambycidae
Diphthera festiva	Noctuidae
Diplognatha sp.	Scarabaeidae
Diplotaxis sp.	Scarabaeidae
Diptera, species	
Discestra trifolii	Noctuidae
Disonycha sp.	Chrysomelidae
Dolerus sp.	Tenthredinidae
Dolichopodidae, species	
Dolycoris baccarum	Pentatomidae
Dorcus sp.	Lucanidae
Doryctinae, species	Braconidae
Dorymyrmex sp.	Formicidae
Dorytomus sp.	Curculionidae
Draeculacephala clypeata	Cicadellidae
Drasterius bimaculatus	Elateridae
Drasterius sp.	Elateridae
Drosophilidae, species	
Drymus sylvaticus	Rhyparochromidae
Dryocoetes autographus	Curculionidae: Scolytinae
Dryocoetes sp.	Curculionidae:

Pest	Family
	Scolytinae
Dryocoetes villosus	Curculionidae: Scolytinae
Dynastinae, species	Scarabaeidae
Dysdercus mimus	Pyrrhocoridae
Dysdercus sp.	Pyrrhocoridae
Dysides obscurus	Bostrichidae
Dysmicoccus neobrevipes	Pseudococcidae
Eburia stigmatica	Cerambycidae
Edessa sp.	Pentatomidae
Elachistidae, species	
Elaphidion sp.	Cerambycidae
Elaphria sp.	Noctuidae
Elateridae, species	
Elaterinae, species	Elateridae
Eleodes sp.	Tenebrionidae
Embioptera, species	
Emblethis denticollis	Rhyparochromidae
Emblethis vicarius	Rhyparochromidae
Emesinae, species	Reduviidae
Empicoris sp.	Reduviidae
Empididae, species	
Encyrtinae, species	Encyrtidae
Endomychidae, species	
Enopliinae, species	Cleridae
Entiminae, species	Curculionidae
Entomobryidae, species	
Enyo lugubris	Sphingidae
Ephestia elutella	Pyralidae
Ephestia kuehniella	Pyralidae
Epicauta sp.	Meloidae
Epitragus sp.	Tenebrionidae
Epitrix sp.	Chrysomelidae
Eremocoris fenestratus	Rhyparochromidae
Eremocoris sp.	Rhyparochromidae
Eriococcidae, species	
Ernobius mollis	Anobiidae
Ernobius sp.	Anobiidae
Erotylidae, species	
Erthesina fullo	Pentatomidae
Estigmene acrea	Arctiidae
Eubulus sp.	Curculionidae
Euconocephalus sp.	Tettigoniidae

Pest	Family
Euetheola bidentata	Scarabaeidae
Euetheola sp.	Scarabaeidae
Eulophinae, species	Eulophidae
Eumeninae, species	Vespidae
Euphoria sp.	Scarabaeidae
Euplatypus parallelus	Platypodidae
Eurydema oleraceum	Pentatomidae
Eurydema ornatum	Pentatomidae
Eurydema ventrale	Pentatomidae
Euryscelis suturalis	Cerambycidae
Eurythyrea sp.	Buprestidae
Eurytoma spessivtsevi	Eurytomidae
Euschistus cornutus	Pentatomidae
Euschistus servus	Pentatomidae
Euschistus strenuus	Pentatomidae
Euwallacea andamanensis	Curculionidae: Scolytinae
Euwallacea validus	Curculionidae: Scolytinae
Exora sp.	Chrysomelidae
Eyprepocnemis plorans	Acrididae
Eysarcoris ventralis	Pentatomidae
Fannia sp.	Muscidae
Feltiella acarisuga	Cecidomyiidae
Forcipomyia sp.	Ceratopogonidae
Formica sp.	Formicidae
Formicidae, species	
Formicinae, species	Formicidae
Frankliniella sp.	Thripidae
Froeschneria piligera	Rhyparochromidae
Froggattiella penicillata	Diaspididae
Fulvius sp.	Miridae
Galeruca sp.	Chrysomelidae
Galerucella luteola	Chrysomelidae
Galerucella sp.	Chrysomelidae
Galleriinae, species	Pyralidae
Gastrodes abietum	Rhyparochromidae
Gastrodes grossipes	Rhyparochromidae
Gastrophysa polygoni	Chrysomelidae
Gelechiidae, species	
Gelechioidea, species	
Geocoris megacephalus	Geocoridae
Geocoris sp.	Geocoridae

Pest	Family
Geometridae, species	
Geotomus punctulatus	Cydnidae
Gerstaeckeria sp.	Curculionidae
Giraudiella inclusa	Cecidomyiidae
Glenea sp.	Cerambycidae
Glyphidocera sp.	Glyphidoceridae
Glyptotermes fuscus	Kalotermitidae
Glyptotermes sp.	Kalotermitidae
Gnaphalodes trachyderoides	Cerambycidae
Gnathamitermes sp.	Termitidae
Gnathotrichus denticulatus	Curculionidae: Scolytinae
Gnathotrichus materiarius	Curculionidae: Scolytinae
Gnathotrichus sp.	Curculionidae: Scolytinae
Gnathotrichus sulcatus	Curculionidae: Scolytinae
Gonioctena sp.	Chrysomelidae
Gonocephalum sp.	Tenebrionidae
Gonocerus acuteangulatus	Coreidae
Gonocerus sp.	Coreidae
Gonocerus venator	Coreidae
Gracilia minuta	Cerambycidae
Grammophorus sp.	Elateridae
Graphosoma sp.	Pentatomidae
Gryllidae, species	
Gryllinae, species	Gryllidae
Gryllodes sigillatus	Gryllidae
Gryllodes sp.	Gryllidae
Gryllodes supplicans	Gryllidae
Gryllus bimaculatus	Gryllidae
Gryllus campestris	Gryllidae
Gryllus rubens	Gryllidae
Gryllus sp.	Gryllidae
Gymnandrosoma sp.	Tortricidae
Gypona sp.	Cicadellidae
Hadeninae, species	Noctuidae
Halyomorpha halys	Pentatomidae
Halyomorpha picus	Pentatomidae
Haplothrips gowdeyi	Phlaeothripidae
Harmonia axyridis	Coccinellidae
Harmonia sp.	Coccinellidae
Harpalus sp.	Carabidae

Pest	Family
Heilipus sp.	Curculionidae
Heleomyzidae, species	
Helicoverpa armigera	Noctuidae
Helicoverpa sp.	Noctuidae
Helicoverpa zea	Noctuidae
Helophorus sp.	Hydrophilidae
Hemerobiidae, species	
Hemieuxoa rudens	Noctuidae
Hemiptera, species	
Hepialidae, species	
Heraeus sp.	Rhyparochromidae
Hermetia illucens	Stratiomyidae
Hermetia sp.	Stratiomyidae
Herpetogramma sp.	Crambidae
Hesperiidae, species	
Hesperophanes campestris	Cerambycidae
Hesperophanes sp.	Cerambycidae
Heterobostrychus aequalis	Bostrichidae
Heterobostrychus brunneus	Bostrichidae
Heterobostrychus hamatipennis	Bostrichidae
Heterobostrychus sp.	Bostrichidae
Heterogaster urticae	Heterogastridae
Hemiptera, species	
Heterotermes aureus	Rhinotermitidae
Heterotermes sp.	Rhinotermitidae
Heterotermes tenuis	Rhinotermitidae
Hippodamia variegata	Coccinellidae
Hippopsis sp.	Cerambycidae
Histeridae, species	
Holcostethus sphacelatus	Pentatomidae
Holcostethus vernalis	Pentatomidae
Homalodisca sp.	Cicadellidae
Homoeocerus marginellus	Coreidae
Hoplandrothrips sp.	Phlaeothripidae
Hortensia similis	Cicadellidae
Horvathiolus superbus	Lygaeidae
Hyalochilus ovatulus	Rhyparochromidae
Hybosorus sp.	Scarabaeidae
Hylastes angustatus	Curculionidae: Scolytinae
Hylastes ater	Curculionidae: Scolytinae
Hylastes attenuatus	Curculionidae:

Pest	Family
	Scolytinae
Hylastes cunicularius	Curculionidae: Scolytinae
Hylastes linearis	Curculionidae: Scolytinae
Hylastes opacus	Curculionidae: Scolytinae
Hylastes sp.	Curculionidae: Scolytinae
Hylecoetus lugubris	Lymexylonidae
Hylesininae, species	Curculionidae: Scolytinae
Hylesinus aculeatus	Curculionidae: Scolytinae
Hylesinus crenatus	Curculionidae: Scolytinae
Hylesinus sp.	Curculionidae: Scolytinae
Hylesinus varius	Curculionidae: Scolytinae
Hylobius abietis	Curculionidae
Hylobius sp.	Curculionidae
Hylocurus sp.	Curculionidae: Scolytinae
Hylotrupes bajulus	Cerambycidae
Hylurgopinus rufipes	Curculionidae: Scolytinae
Hylurgopinus sp.	Curculionidae: Scolytinae
Hylurgops glabrotus	Curculionidae: Scolytinae
Hylurgops incomptus	Curculionidae: Scolytinae
Hylurgops palliatus	Curculionidae: Scolytinae
Hylurgops planirostris	Curculionidae: Scolytinae
Hylurgops sp.	Curculionidae: Scolytinae
Hylurgus ligniperda	Curculionidae: Scolytinae
Hylurgus sp.	Curculionidae: Scolytinae
Hymenoptera, species	
Hypena gonospilalis	Noctuidae
Hypena sp.	Noctuidae
Hypera brunnipennis	Curculionidae
Hypera constans	Curculionidae

Pest	Family
Hypera postica	Curculionidae
Hypera sp.	Curculionidae
Hyphantria cunea	Arctiidae
Hypocassida subferrugines	Chrysomelidae
Hypocryphalus mangiferae	Curculionidae: Scolytinae
Hypocryphalus sp.	Curculionidae: Scolytinae
Hypoponera sp.	Formicidae
Hypothenemus obscurus	Curculionidae: Scolytinae
Hypothenemus sp.	Curculionidae: Scolytinae
Hypurus bertrandi	Curculionidae
Ibalia leucospoides	Ibaliidae
Ibalia sp.	Ibaliidae
Ibaliidae, species	
Ichneumonidae, species	
Icosium tomentosum	Cerambycidae
Idiocerinae, species	Cicadellidae
Idiocerus sp.	Cicadellidae
Incisitermes minor	Kalotermitidae
Incisitermes modestus	Kalotermitidae
Incisitermes sp.	Kalotermitidae
Insect, species	
Insecta, species	
Ips acuminatus	Curculionidae: Scolytinae
Ips amitinus	Curculionidae: Scolytinae
Ips apache	Curculionidae: Scolytinae
Ips bonanseai	Curculionidae: Scolytinae
Ips calligraphus	Curculionidae: Scolytinae
Ips cembrae	Curculionidae: Scolytinae
Ips cribricollis	Curculionidae: Scolytinae
Ips erosus	Curculionidae: Scolytinae
Ips grandicollis	Curculionidae: Scolytinae
Ips integer	Curculionidae: Scolytinae
Ips lecontei	Curculionidae:
	Scolytinae
Ips mannsfeldi	Curculionidae: Scolytinae
Ips mexicanus	Curculionidae: Scolytinae
Ips pini	Curculionidae: Scolytinae
Ips sexdentatus	Curculionidae: Scolytinae
Ips sp.	Curculionidae: Scolytinae
Ips typographus	Curculionidae: Scolytinae
Irbisia sp.	Miridae
Iridomyrmex sp.	Formicidae
Ischnodemus conicus	Blissidae
Ischnodemus sp.	Blissidae
Isopoda, species	
Isoptera, species	
Kalotermes flavicollis	Kalotermitidae
Kalotermes sp.	Kalotermitidae
Kalotermitidae, species	
Kleidocerys resedae	Lygaeidae
Lacon sp.	Elateridae
Laemophloeidae, species	
Lamia sp.	Cerambycidae
Lamia textor	Cerambycidae
Lamiinae, species	Cerambycidae
Lamprodema maurum	Rhyparochromidae
Lampyridae, species	
Languriidae, species	
Largus cinctus	Largidae
Largus sp.	Largidae
Larinus cynarae	Curculionidae
Larinus latus	Curculionidae
Larinus sp.	Curculionidae
Larinus turbinatus	Curculionidae
Lasiochilidae, species	
Lasioderma serricorne	Anobiidae
Lasius alienus	Formicidae
Lasius brunneus	Formicidae
Lasius emarginatus	Formicidae
Lasius niger	Formicidae
Lasius sp.	Formicidae
Latheticus oryzae	Tenebrionidae

Pest	Family
Lathridiidae, species	
Ledomyia sp.	Cecidomyiidae
Leiopus sp.	Cerambycidae
Lepidoptera, species	
Leptoglossus occidentalis	Coreidae
Leptoglossus oppositus	Coreidae
Leptoglossus phyllopus	Coreidae
Leptoglossus sp.	Coreidae
Leptopus marmoratus	Leptopodidae
Leptostylus sp.	Cerambycidae
Leptothorax sp.	Formicidae
Leptothorax subditivus	Formicidae
Leptura sp.	Cerambycidae
Lepyronia quadrangularis	Aphrophoridae
Lestodiplosis sp.	Cecidomyiidae
Lestremia sp.	Cecidomyiidae
Lestremiinae, species	Cecidomyiidae
Leucania sp.	Noctuidae
Ligyrocoris sp.	Rhyparochromidae
Ligyrus sp.	Scarabaeidae
Limothrips cerealium	Thripidae
Linepithema humile	Formicidae
Liogenys macropelma	Scarabaeidae
Liometopum sp.	Formicidae
Liorhyssus hyalinus	Rhopalidae
Liriomyza huidobrensis	Agromyzidae
Lissonotus flavocinctus	Cerambycidae
Listronotus sp.	Curculionidae
Litargus sp.	Mycetophagidae
Lixus sp.	Curculionidae
Lobometopon metallicum	Tenebrionidae
Lonchaea sp.	Lonchaeidae
Longitarsus sp.	Chrysomelidae
Lucanidae, species	
Luprops sp.	Tenebrionidae
Lycaenidae, species	
Lyctidae, species	
Lyctinae, species	Lyctidae
Lyctus africanus	Bostrichidae
Lyctus brunneus	Bostrichidae
Lyctus cavicollis	Bostrichidae
Lyctus simplex	Bostrichidae
Lyctus sp.	Bostrichidae

Pest	Family
Lyctus villosus	Bostrichidae
Lygaeidae, species	
Lygaeoidea, species	
Lygaeosoma sardeum	Lygaeidae
Lygaeus equestris	Lygaeidae
Lygaeus pandurus	Lygaeidae
Lygus gemellatus	Miridae
Lygus rugulipennis	Miridae
Lygus sp.	Miridae
Lymantria dispar	Lymantriidae
Lymantriidae, species	
Lymexylidae, species	
Lyphia sp.	Tenebrionidae
Macrocopturus cribricollis	Curculionidae
Macroglossum stellatarum	Sphingidae
Macroscytus sp.	Cydnidae
Maladera sp.	Scarabaeidae
Malezonotus sodalicius	Rhyparochromidae
Mallodon dasystomus	Cerambycidae
Mallodon sp.	Cerambycidae
Margarodidae, species	
Marshallius sp.	Curculionidae
Mecaspis alternans	Curculionidae
Mecinus circulatus	Curculionidae
Mecinus pyraster	Curculionidae
Mecinus sp.	Curculionidae
Mecopus sp.	Curculionidae
Megacyllene antennatus	Cerambycidae
Megacyllene sp.	Cerambycidae
Megalonotus chiragrus	Rhyparochromidae
Megaselia sp.	Phoridae
Megaspilidae, species	
Melacoryphus lateralis	Lygaeidae
Melalgus sp.	Bostrichidae
Melanaethus subglaber	Cydnidae
Melanaspis elaeagni	Diaspididae
Melanaspis sp.	Diaspididae
Melandryidae, species	
Melanocoryphus albomaculatus	Lygaeidae
Melanophila acuminata	Buprestidae
Melanophila cuspidata	Buprestidae
Melanophila notata	Buprestidae

Pest	Family
Melanophila sp.	Buprestidae
Melanoplus sp.	Acrididae
Melolonthinae, species	Scarabaeidae
Melyridae, species	
Membracidae, species	
Metamasius hemipterus	Dryophthoridae
Metoponium sp.	Tenebrionidae
Metopoplax ditomoides	Oxycarenidae
Metopoplax origani	Oxycarenidae
Metopoplax sp.	Oxycarenidae
Mezira sp.	Aradidae
Micrapate brasiliensis	Bostrichidae
Micrapate labialis	Bostrichidae
Micrapate scabrata	Bostrichidae
Micrapate sp.	Bostrichidae
Micromus angulatus	Hemerobiidae
Micropezidae, species	
Microplax sp.	Oxycarenidae
Microtheca sp.	Chrysomelidae
Migneauxia sp.	Corticariidae
Milichiidae, species	
Minthea obstita	Bostrichidae
Minthea rugicollis	Bostrichidae
Minthea sp.	Bostrichidae
Minthea squamigera	Bostrichidae
Miridae, species	
Mocis frugalis	Noctuidae
Mocis undata	Noctuidae
Mogoplistidae, species	
Molorchus minor	Cerambycidae
Molorchus sp.	Cerambycidae
Molytinae, species	Curculionidae
Monarthrum sp.	Curculionidae: Scolytinae
Monochamus alternatus	Cerambycidae
Monochamus carolinensis	Cerambycidae
Monochamus clamator	Cerambycidae
Monochamus galloprovincialis	Cerambycidae
Monochamus sartor	Cerambycidae
Monochamus scutellatus	Cerambycidae
Monochamus sp.	Cerambycidae
Monochamus sutor	Cerambycidae
Monochamus teserula	Cerambycidae

Pest	Family
Monommatidae, species	
Monomorium destructor	Formicidae
Monomorium floricola	Formicidae
Monomorium pharaonis	Formicidae
Monomorium salomonis	Formicidae
Monomorium sp.	Formicidae
Monosteira unicostata	Tingidae
Monotomidae, species	
Mordellidae, species	
Mormidea sp.	Pentatomidae
Muscidae, species	
Mycetophagidae, species	
Mycetophilidae, species	
Myllocerus hilleri	Curculionidae
Myocalandra sp.	Dryophthoridae
Myochrous sp.	Chrysomelidae
Myrmicinae, species	Formicidae
Nabidae, species	
Nabis sp.	Nabidae
Naemia seriata	Coccinellidae
Nasutitermes costalis	Termitidae
Nasutitermes ephratae	Termitidae
Nasutitermes nigriceps	Termitidae
Nasutitermes sp.	Termitidae
Nathrius brevipennis	Cerambycidae
Necrobia rufipes	Cleridae
Nemapogon granella	Tineidae
Nemapogon sp.	Tineidae
Nematocera, species	
Neoclytus caprea	Cerambycidae
Neoclytus olivaceus	Cerambycidae
Neoclytus sp.	Cerambycidae
Neoconocephalus punctipes	Tettigoniidae
Neoconocephalus sp.	Tettigoniidae
Neoconocephalus triops	Tettigoniidae
Neotermes connezus	Kalotermitidae
Neotermes modestus	Kalotermitidae
Neotermes sp.	Kalotermitidae
Neotrichus latiusculus	Zopheridae
Neottiglossa sp.	Pentatomidae
Neuroptera, species	
Nezara viridula	Pentatomidae
Niphades sp.	Curculionidae

Pest	Family
Niphades variegatus	Curculionidae
Nitidulidae, species	
Noctua comes	Noctuidae
Noctua pronuba	Noctuidae
Noctuidae, species	
Noctuinae, species	Noctuidae
Nymphalidae, species	
Nysius ericae	Lygaeidae
Nysius graminicola	Lygaeidae
Nysius senecionis	Lygaeidae
Nysius sp.	Lygaeidae
Nysius stalianus	Lygaeidae
Nysius thymi	Lygaeidae
Nyssodrysternum sp.	Cerambycidae
Nyssonotus seriatus	Curculionidae
Ochetellus sp.	Formicidae
Ochrimnus carnosulus	Lygaeidae
Odontocera sp.	Cerambycidae
Odontocolon sp.	Ichneumonidae
Oebalus pugnax	Pentatomidae
Oecophoridae, species	
Oedemeridae, species	
Olenecamptus sp.	Cerambycidae
Olethreutinae, species	Tortricidae
Omalus sp.	Chrysididae
Omophlus sp.	Tenebrionidae
Onthophagus sp.	Scarabaeidae
Opatrinae, species	Tenebrionidae
Opogona sacchari	Tineidae
Opogona sp.	Tineidae
Orphinus sp.	Dermestidae
Orthocentrinae, species	Ichneumonidae
Orthostethus sp.	Elateridae
Orthotomicus caelatus	Curculionidae: Scolytinae
Orthotomicus erosus	Curculionidae: Scolytinae
Orthotomicus laricis	Curculionidae: Scolytinae
Orthotomicus proximus	Curculionidae: Scolytinae
Orthotomicus sp.	Curculionidae: Scolytinae
Orthotomicus suturalis	Curculionidae: Scolytinae

Pest	Family
Oryctes rhinoceros	Scarabaeidae
Osbornellus sp.	Cicadellidae
Otiorhynchus sp.	Curculionidae
Otitidae, species	
Oulema melanopus	Chrysomelidae
Oulema sp.	Chrysomelidae
Ovalisia sp.	Buprestidae
Oxya velox	Acrididae
Oxycarenus pallens	Oxycarenidae
Oxycarenus sp.	Oxycarenidae
Oxygrylius ruginasus	Scarabaeidae
Oxypleurus nodieri	Cerambycidae
Ozophora sp.	Rhyparochromidae
Pachybrachius sp.	Rhyparochromidae
Pachydissus sp.	Cerambycidae
Pagiocerus sp.	Curculionidae: Scolytinae
Palaeocallidium rufipenne	Cerambycidae
Palaeocallidium sp.	Cerambycidae
Palomena prasina	Pentatomidae
Palorus subdepressus	Tenebrionidae
Pangaeus rugiceps	Cydnidae
Paralipsa gularis	Pyralidae
Paraparomius lateralis	Rhyparochromidae
Parasaissetia nigra	Coccidae
Paratenetus sp.	Tenebrionidae
Paratrechina longicornis	Formicidae
Paratrechina sp.	Formicidae
Pareuchaetes insulata	Arctiidae
Parlatoria blanchardi	Diaspididae
Paromius gracilis	Rhyparochromidae
Passandridae, species	
Pectinophora gossypiella	Gelechiidae
Peltophorus sp.	Curculionidae
Pentatomidae, species	
Perapion curtirostre	Apionidae
Perissus delerei	Cerambycidae
Peritrechus gracilicornis	Rhyparochromidae
Perniphora robusta	Pteromalidae
Phaedon cochleariae	Chrysomelidae
Phaedon sp.	Chrysomelidae
Phaenops sp.	Buprestidae
Pheidole megacephala	Formicidae

Pest	Family
Pheidole sp.	Formicidae
Philaenus spumarius	Cercopidae
Phlaeothripidae, species	
Phloeosinus canadensis	Curculionidae: Scolytinae
Phloeosinus punctatus	Curculionidae: Scolytinae
Phloeosinus rudis	Curculionidae: Scolytinae
Phloeosinus sp.	Curculionidae: Scolytinae
Phloeotribus scarabaeoides	Curculionidae: Scolytinae
Phloeotribus sp.	Curculionidae: Scolytinae
Phlogophora meticulosa	Noctuidae
Phoracantha recurva	Cerambycidae
Phoracantha semipunctata	Cerambycidae
Phoracantha sp.	Cerambycidae
Phoridae, species	
Phragmatobia fuliginosa	Arctiidae
Phratora sp.	Chrysomelidae
Phycitinae, species	Pyralidae
Phylinae, species	Miridae
Phyllobaenus sp.	Cleridae
Phyllobius sp.	Curculionidae
Phyllophaga sp.	Scarabaeidae
Phyllotreta sp.	Chrysomelidae
Phymatidae, species	
Phymatodes sp.	Cerambycidae
Phymatodes testaceus	Cerambycidae
Physonota sp.	Chrysomelidae
Phytocoris sp.	Miridae
Pieridae, species	
Pieris brassicae	Pieridae
Piezodorus purus	Pentatomidae
Pimplinae, species	Ichneumonidae
Pissodes castaneus	Curculionidae
Pissodes harcyniae	Curculionidae
Pissodes notatus	Curculionidae
Pissodes pini	Curculionidae
Pissodes sp.	Curculionidae
Pityogenes bidentatus	Curculionidae: Scolytinae
Pityogenes bistridentatus	Curculionidae:

Pest	Family
	Scolytinae
Pityogenes calcaratus	Curculionidae: Scolytinae
Pityogenes chalcographus	Curculionidae: Scolytinae
Pityogenes quadridens	Curculionidae: Scolytinae
Pityogenes sp.	Curculionidae: Scolytinae
Pityogenes trepanatus	Curculionidae: Scolytinae
Pityokteines curvidens	Curculionidae: Scolytinae
Pityokteines sp.	Curculionidae: Scolytinae
Pityokteines spinidens	Curculionidae: Scolytinae
Pityophthorus mexicanus	Curculionidae: Scolytinae
Pityophthorus pityographus	Curculionidae: Scolytinae
Pityophthorus sp.	Curculionidae: Scolytinae
Placonotus sp.	Laemophloeidae
Placopsidella sp.	Ephydridae
Placosternus difficilis	Cerambycidae
Placosternus sp.	Cerambycidae
Plagionotus christophi	Cerambycidae
Plagionotus sp.	Cerambycidae
Planococcus halli	Pseudococcidae
Platycleis sp.	Tettigoniidae
Platynota sp.	Tortricidae
Platyplax salviae	Heterogastridae
Platypodidae, species	
Platypus sp.	Platypodidae
Plodia interpunctella	Pyralidae
Plusiinae, species	Noctuidae
Plutella xylostella	Plutellidae
Podagrica malvae	Chrysomelidae
Podagrica sp.	Chrysomelidae
Pogonocherus hispidus	Cerambycidae
Pogonocherus perroudi	Cerambycidae
Pogonocherus sp.	Cerambycidae
Pogonomyrmex maricopa	Formicidae
Pollenia sp.	Calliphoridae
Polycesta sp.	Buprestidae

Pest	Family
Polydrusus sp.	Curculionidae
Polygraphus poligraphus	Curculionidae: Scolytinae
Polygraphus rufipennis	Curculionidae: Scolytinae
Polygraphus sp.	Curculionidae: Scolytinae
Polygraphus subopacus	Curculionidae: Scolytinae
Polyrhachis sp.	Formicidae
Ponera sp.	Formicidae
Ponerinae, species	Formicidae
Porricondylinae, species	Cecidomyiidae
Prioninae, species	Cerambycidae
Prionus californicus	Cerambycidae
Prionus sp.	Cerambycidae
Prosoplus sp.	Cerambycidae
Prostemma guttula	Nabidae
Prostephanus sp.	Bostrichidae
Prostephanus truncatus	Bostrichidae
Protaetia orientalis	Scarabaeidae
Proxys punctulatus	Pentatomidae
Psenulus sp.	Sphecidae
Pseudococcidae, species	
Pseudococcus longispinus	Pseudococcidae
Pseudohylesinus variegatus	Curculionidae: Scolytinae
Pseudomyrmex sp.	Formicidae
Pseudopamera aurivilliana	Rhyparochromidae
Pseudopamera sp.	Rhyparochromidae
Pseudopityophthorus sp.	Curculionidae: Scolytinae
Pseudopityophthorus yavapaii	Curculionidae: Scolytinae
Pseudothysanoes sp.	Curculionidae: Scolytinae
Psocidae, species	
Psocoptera, species	
Psychidae, species	
Psychodidae, species	
Psyllidae, species	
Psylliodes sp.	Chrysomelidae
Pteleobius vittatus	Curculionidae: Scolytinae
Pterolophia sp.	Cerambycidae

Pest	Family
Pteromalidae, species	
Ptiliidae, species	
Ptilinus sp.	Anobiidae
Ptinidae, species	
Pycnarmon cribrata	Pyralidae
Pyralidae, species	
Pyralis farinalis	Pyralidae
Pyraustinae, species	Crambidae
Pyrgocorypha sp.	Tettigoniidae
Pyrochroidae, species	
Pyrrhalta sp.	Chrysomelidae
Pyrrhidium sanguineum	Cerambycidae
Pyrrhidium sp.	Cerambycidae
Pyrrhocoris apterus	Pyrrhocoridae
Rachiplusia ou	Noctuidae
Raglius alboacuminatus	Rhyparochromidae
Reduviidae, species	
Renia discoloralis	Noctuidae
Reticulitermes chinensis	Rhinotermitidae
Reticulitermes flavipes	Rhinotermitidae
Reticulitermes lucifugus	Rhinotermitidae
Reticulitermes sp.	Rhinotermitidae
Reticulitermes tibialis	Rhinotermitidae
Reuteroscopus sp.	Miridae
Rhagionidae, species	
Rhagium inquisitor	Cerambycidae
Rhagium mordax	Cerambycidae
Rhagium sp.	Cerambycidae
Rhaphidophoridae, species	
Rhaphigaster nebulosa	Pentatomidae
Rhinotermitidae, species	
Rhopalidae, species	
Rhopalus parumpunctatus	Rhopalidae
Rhopalus sp.	Rhopalidae
Rhopalus subrufus	Rhopalidae
Rhopalus tigrinus	Rhopalidae
Rhynchaenus sp.	Curculionidae
Rhynchites bacchus	Curculionidae
Rhynchitidae, species	
Rhynchophorus palmarum	Dryophthoridae
Rhyncolus elongatus	Curculionidae
Rhyncolus sculpturatus	Curculionidae
Rhyncolus sp.	Curculionidae

Pest	Family
Rhyparida sp.	Chrysomelidae
Rhyparochromidae, species	
Rhyparochromus confusus	Rhyparochromidae
Rhyparochromus pini	Rhyparochromidae
Rhyparochromus quadratus	Rhyparochromidae
Rhyparochromus sp.	Rhyparochromidae
Rhyparochromus vulgaris	Rhyparochromidae
Rhyssomatus sp.	Curculionidae
Rhytidoderes plicatus	Curculionidae
Rhytidodus decimaquartus	Cicadellidae
Rhyzopertha dominica	Bostrichidae
Ricania fumosa	Ricaniidae
Riodinidae, species	
Ropica sp.	Cerambycidae
Rugitermes sp.	Kalotermitidae
Saissetia sp.	Coccidae
Salpingidae, species	
Sambus sp.	Buprestidae
Saperda carcharias	Cerambycidae
Saperda scalaris	Cerambycidae
Saperda sp.	Cerambycidae
Scantius aegyptius	Pyrrhocoridae
Scaphidiinae, species	Staphylinidae
Scarabaeidae, species	
Scatopsidae, species	
Sciaridae, species	
Sciocoris maculatus	Pentatomidae
Sciocoris sp.	Pentatomidae
Scolopostethus affinis	Rhyparochromidae
Scolopostethus decoratus	Rhyparochromidae
Scolytinae, species	Curculionidae: Scolytinae
Scolytodes sp.	Curculionidae: Scolytinae
Scolytoplatypus sp.	Curculionidae: Scolytinae
Scolytus intricatus	Curculionidae: Scolytinae
Scolytus multistriatus	Curculionidae: Scolytinae
Scolytus ratzeburgi	Curculionidae: Scolytinae
Scolytus rugulosus	Curculionidae: Scolytinae
Scolytus schevyrewi	Curculionidae:

Pest	Family
	Scolytinae
Scolytus scolytus	Curculionidae: Scolytinae
Scolytus sp.	Curculionidae: Scolytinae
Scotinophara sp.	Pentatomidae
Scydmaenidae, species	
Scyphophorus acupunctatus	Dryophthoridae
Scyphophorus sp.	Dryophthoridae
Scythridinae, species	Coleophoridae
Sehirinae, species	Cydnidae
Sehirus bicolor	Cydnidae
Selepa sp.	Noctuidae
Semanotus sp.	Cerambycidae
Semiothisa sp.	Geometridae
Sericoderus sp.	Corylophidae
Serropalpus barbatus	Melandryidae
Serropalpus sp.	Melandryidae
Sesiidae, species	
Setomorpha rutella	Tineidae
Shirahoshizo sp.	Curculionidae
Silvanidae, species	
Silvanus planatus	Silvanidae
Silvanus sp.	Silvanidae
Sinoxylon anale	Bostrichidae
Sinoxylon conigerum	Bostrichidae
Sinoxylon crassum	Bostrichidae
Sinoxylon indicum	Bostrichidae
Sinoxylon sp.	Bostrichidae
Sipalinus gigas	Dryophthoridae
Sipalinus sp.	Dryophthoridae
Sirex cyaneus	Siricidae
Sirex juvencus	Siricidae
Sirex nitobei	Siricidae
Sirex noctilio	Siricidae
Sirex sp.	Siricidae
Siricidae, species	
Sitona crinita	Curculionidae
Sitona discoideus	Curculionidae
Sitona hispidulus	Curculionidae
Sitona humeralis	Curculionidae
Sitona sp.	Curculionidae
Sitophilus sp.	Dryophthoridae

Pest	Family
Situlaspis yuccae	Diaspididae
Smicronyx interruptus	Curculionidae
Smicronyx sp.	Curculionidae
Sminthuridae, species	
Solenopsis geminata	Formicidae
Solenopsis invicta	Formicidae
Solenopsis sp.	Formicidae
Solenopsis xyloni	Formicidae
Spermophagus sericeus	Bruchidae
Spermophagus sp.	Bruchidae
Sphacophilus sp.	Argidae
Sphaeridiinae, species	Hydrophilidae
Sphaeroceridae, species	
Sphecidae, species	
Sphenophorus sp.	Dryophthoridae
Sphenoptera sp.	Buprestidae
Sphingidae, species	
Sphingonotus sp.	Acrididae
Spilosoma lubricipeda	Arctiidae
Spilosoma sp.	Arctiidae
Spilostethus pandurus	Lygaeidae
Spodoptera frugiperda	Noctuidae
Spodoptera litura	Noctuidae
Spodoptera sp.	Noctuidae
Stagonomus pusillus	Pentatomidae
Staphylinidae, species	
Stegobium paniceum	Anobiidae
Steirastoma sp.	Cerambycidae
Stenocarus fuliginosus	Curculionidae
Stenodontes sp.	Cerambycidae
Stenoscelis sp.	Curculionidae
Stephanopachys quadricollis	Bostrichidae
Stephanopachys rugosus	Bostrichidae
Stephanopachys sp.	Bostrichidae
Sternochetus mangiferae	Curculionidae
Sternochetus sp.	Curculionidae
Stictopleurus crassicornis	Rhopalidae
Stictopleurus sp.	Rhopalidae
Stizocera sp.	Cerambycidae
Stratiomyidae, species	
Stromatium barbatum	Cerambycidae
Stromatium longicorne	Cerambycidae
Stromatium sp.	Cerambycidae

Pest	Family
Strophosoma melanogrammum	Curculionidae
Sympiesis sp.	Eulophidae
Synanthedon sp.	Sesiidae
Synchroa punctata	Synchroidae
Syngrapha celsa	Noctuidae
Syphrea sp.	Chrysomelidae
Syrphidae, species	
Systena sp.	Chrysomelidae
Tachinidae, species	
Tachyporinae, species	Staphylinidae
Taphropeltus contractus	Rhyparochromidae
Taphrorychus bicolor	Curculionidae: Scolytinae
Taphrorychus sp.	Curculionidae: Scolytinae
Taphrorychus villifrons	Curculionidae: Scolytinae
Tapinoma melanocephalum	Formicidae
Tapinoma sp.	Formicidae
Targionia vitis	Diaspididae
Tarsostenus univittatus	Cleridae
Teleogryllus commodus	Gryllidae
Teleogryllus mitratus	Gryllidae
Teleogryllus sp.	Gryllidae
Tenebrionidae, species	
Tenthredinidae, species	
Tentyria sp.	Tenebrionidae
Tephritidae, species	
Tephritis sp.	Tephritidae
Termes panamaensis	Termitidae
Termitidae, species	
Tessaratomidae, species	
Tesserocerus sp.	Platypodidae
Tetramorium bicarinatum	Formicidae
Tetramorium caespitum	Formicidae
Tetramorium sp.	Formicidae
Tetraponera rufonigra	Formicidae
Tetrapriocera longicornis	Bostrichidae
Tetrigidae, species	
Tetropium castaneum	Cerambycidae
Tetropium fuscum	Cerambycidae
Tetropium gabrieli	Cerambycidae
Tetropium sp.	Cerambycidae
Tettigoniidae, species	

Pest	Family
Thripidae, species	
Thrips meridionalis	Thripidae
Thrips palmi	Thripidae
Thyanta pallidovirens	Pentatomidae
Thyreocoris scarabaeoides	Thyreocoridae
Thysanoptera, species	
Tineidae, species	
Tingidae, species	
Tipula marmorata	Tipulidae
Tipula sp.	Tipulidae
Tipulidae, species	
Tolype sp.	Lasiocampidae
Tomarus sp.	Scarabaeidae
Tomaspis inca	Cercopidae
Tomicus minor	Curculionidae: Scolytinae
Tomicus piniperda	Curculionidae: Scolytinae
Tomicus sp.	Curculionidae: Scolytinae
Tomolips sp.	Curculionidae
Tortricidae, species	
Torymus sp.	Torymidae
Trachyderes sp.	Cerambycidae
Tremex fusicornis	Siricidae
Tremex sp.	Siricidae
Tribolium castaneum	Tenebrionidae
Tribolium sp.	Tenebrionidae
Trichoferus sp.	Cerambycidae
Trichophaga sp.	Tineidae
Trichoplusia ni	Noctuidae
Trigonorhinus sp.	Anthribidae
Trimerotropis pallidipennis	Acrididae
Trirhabda sp.	Chrysomelidae
Trogoderma granarium	Dermestidae
Trogoderma sp.	Dermestidae
Trogoderma variabile	Dermestidae
Trogossitidae, species	
Trogoxylon praeustum	Lyctidae
Trogoxylon sp.	Lyctidae
Tropicanus sp.	Cicadellidae
Tropidothorax leucopterus	Lygaeidae
Tropistethus sp.	Lygaeidae
Trypodendron domesticum	Curculionidae:

Pest	Family
	Scolytinae
Trypodendron lineatum	Curculionidae: Scolytinae
Trypodendron signatum	Curculionidae: Scolytinae
Trypodendron sp.	Curculionidae: Scolytinae
Tychius sp.	Curculionidae
Typhaea stercorea	Mycetophagidae
Typhlocybinae, species	Cicadellidae
Typophorus sp.	Chrysomelidae
Ulus sp.	Tenebrionidae
Urgleptes sp.	Cerambycidae
Urocerus gigas	Siricidae
Urocerus sp.	Siricidae
Uroleucon sp.	Aphididae
Vespidae, species	
Vespula germanica	Vespidae
Wasmannia auropunctata	Formicidae
Wroughtonia sp.	Braconidae
Xanthochilus saturnius	Rhyparochromidae
Xanthogaleruca luteola	Chrysomelidae
Xeris sp.	Siricidae
Xeris spectrum	Siricidae
Xestocephalus sp.	Cicadellidae
Xiphydriidae, species	
Xyleborinus saxeseni	Curculionidae: Scolytinae
Xyleborinus sp.	Curculionidae: Scolytinae
Xyleborus affinis	Curculionidae: Scolytinae
Xyleborus apicalis	Curculionidae: Scolytinae
Xyleborus eurygraphus	Curculionidae: Scolytinae
Xyleborus ferrugineus	Curculionidae: Scolytinae
Xyleborus intrusus	Curculionidae: Scolytinae
Xyleborus sp.	Curculionidae: Scolytinae
Xyleborus volvulus	Curculionidae: Scolytinae
Xylechinus pilosus	Curculionidae: Scolytinae
Xylechinus sp.	Curculionidae:

Pest	Family
	Scolytinae
Xylobiops sp.	Bostrichidae
Xylobiops texanus	Bostrichidae
Xylocopa sp.	Xylocopidae
Xylodiplosis sp.	Cecidomyiidae
Xylomyidae, species	
Xyloperthella picea	Bostrichidae
Xyloperthodes nitidipennis	Bostrichidae
Xyloperthodes sp.	Bostrichidae
Xylophagus sp.	Xylophagidae
Xylopsocus capucinus	Bostrichidae
Xyloryctes fureata	Scarabaeidae
Xylosandrus crassiusculus	Curculionidae: Scolytinae
Xylosandrus germanus	Curculionidae: Scolytinae
Xylosandrus morigerus	Curculionidae: Scolytinae
Xylosandrus sp.	Curculionidae: Scolytinae
Xylothrips flavipes	Bostrichidae
Xylotrechus grayi	Cerambycidae
Xylotrechus magnicollis	Cerambycidae
Xylotrechus rusticus	Cerambycidae
Xylotrechus sp.	Cerambycidae
Xylotrechus stebbingi	Cerambycidae
Xylotrupes gideon	Scarabaeidae
Xystrocera globosa	Cerambycidae
Xystrocera sp.	Cerambycidae
Yponomeutidae, species	
Zabrotes subfasciatus	Bruchidae
Zacryptocerus sp.	Formicidae
Zacryptocerus umbraculatus	Formicidae
Zascelis sp.	Curculionidae
Zootermopsis laticeps	Hodotermitidae
Zootermopsis sp.	Hodotermitidae
Zopheridae, species	
Zophobas sp.	Tenebrionidae
Zygogramma sp.	Chrysomelidae
Zygopinae, species	Curculionidae
Zygops sp.	Curculionidae
Mites and Ticks	
Allothrombium sp.	Trombidiidae

Pest	Family
Ameroseius sp.	Ameroseiidae
Araneae, species	
Araneidae, species	
Argas sanchezi	Argasidae
Ascidae, species	
Balaustium sp.	Erythraeidae
Bdella sp.	Bdellidae
Bdellidae, species	
Blattisocius sp.	Ascidae
Cheyletidae, species	
Cosmoglyphus sp.	Acaridae
Cryptostigmata, species	
Erythraeidae, species	
Glycyphagus destructor	Glycyphagidae
Hemicheyletia serrula	Cheyletidae
Ixodes hexagonus	Ixodidae
Melichares sp.	Ascidae
Mesostigmata, species	
Oribatida, species	
Pediculaster sp.	Pygmephoridae
Phytoseiidae, species	
Proctolaelaps sp.	Ascidae
Pygmephoridae, species	
Rhipicephalus sanguineus	Ixodidae
Schwiebea sp.	Acaridae
Stigmaeidae, species	
Tetranychus (tetranychus)	Tetranychidae
Tetranychus sp.	Tetranychidae
Trombidiidae, species	
Uropodidae, species	
Mollusks	
Achatina (lissachatina)	Achatinidae
Achatina sp.	Achatinidae
Acusta despecta	Bradybaenidae
Acusta tourannensis	Bradybaenidae
Agriolimax reticulatus	Agriolimacidae
Allopeas clavulinum	Subulinidae
Arianta arbustorum	Helicidae
Arion (kobeltia)	Arionidae
Arion (mesarion)	Arionidae
Arion sp.	Arionidae
Assimineidae, species	

Pest	Family
Balea perversa	Clausiliidae
Bradybaena seiboldtiana	Bradybaenidae
Bradybaena similaris	Bradybaenidae
Bradybaena sp.	Bradybaenidae
Bradybaenidae, species	
Bulimulidae, species	
Bulimulus guadalupensis	Bulimulidae
Bulimulus sp.	Bulimulidae
Bulimulus tenuissimus	Bulimulidae
Calcisuccinea campestris	Succineidae
Candidula gigaxii	Hygromiidae
Candidula intersecta	Hygromiidae
Candidula sp.	Hygromiidae
Candidula unifasciata	Hygromiidae
Cantareus apertus	Helicidae
Cathaica fasciola	Bradybaenidae
Cathaica sp.	Bradybaenidae
Cepaea cf.	Helicidae
Cepaea hortensis	Helicidae
Cepaea nemoralis	Helicidae
Cepaea sp.	Helicidae
Cernuella (xerocincta)	Hygromiidae
Cernuella cf.	Hygromiidae
Cernuella cisalpina	Hygromiidae
Cernuella sp.	Hygromiidae
Cernuella virgata	Hygromiidae
Charpentieria (itala)	Clausiliidae
Chilostoma cingulata	Helicidae
Chilostoma cornea	Helicidae
Clausilia rugosa	Clausiliidae
Clausilia sp.	Clausiliidae
Clausiliidae, species	
Cochlicella acuta	Cochlicellidae
Cochlicella conoidea	Cochlicellidae
Cochlicopa lubrica	Cionellidae
Cochlodina laminata	Clausiliidae
Cornu aspersum	Helicidae
Cryptozona siamensis	Ariophantidae
Deroceras laeve	Agriolimacidae
Deroceras panormitanum	Agriolimacidae
Deroceras sp.	Agriolimacidae
Discidae, species	
Discus rotundatus	Discidae

Pest	Family
Drymaeus (mesembrinus)	Bulimulidae
Enidae, species	
Eobania constantinae	Helicidae
Eobania vermiculata	Helicidae
Euhadra sp.	Bradybaenidae
Fruticicola fruticum	Bradybaenidae
Galba truncatula	Lymnaeidae
Granaria illyrica	Chondrinidae
Helicarion sp.	Helicarionidae
Helicarionidae, species	
Helicella itala	Hygromiidae
Helicella maritima	Hygromiidae
Helicella neglecta	Hygromiidae
Helicella sp.	Hygromiidae
Helicella variabilis	Hygromiidae
Helicella virgata	Hygromiidae
Helicellidae, species	
Helicellinae, species	Hygromiidae
Helicidae, species	
Helicina (striatemoda)	Helicinidae
Helicodonta obvoluta	Helicodontidae
Helicodonta sp.	Helicodontidae
Helix cincta	Helicidae
Helix lucorum	Helicidae
Helix sp.	Helicidae
Hygromia cinctella	Hygromiidae
Hygromiidae, species	
Karaftahelix blakeana	Bradybaenidae
Lauria cylindracea	Pupillidae
Lehmannia valentiana	Limacidae
Limacidae, species	
Limacus maculatus	Limacidae
Limax cf.	Limacidae
Limax cinereoniger	Limacidae
Limax marginatus	Limacidae
Limax maximus	Limacidae
Limax sp.	Limacidae
Lymnaea sp.	Lymnaeidae
Marmorana sp.	Helicidae
Massylaea punica	Helicidae
Merdigera obscura	Enidae
Merdighera obscura	Enidae
Microxeromagna armillata	Hygromiidae

Pest	Family
Mollusca, species	
Monacha bincinctae	Hygromiidae
Monacha cantiana	Hygromiidae
Monacha cartusiana	Hygromiidae
Monacha cf.	Hygromiidae
Monacha sp.	Hygromiidae
Monachoides glabella	Hygromiidae
Monachoides incarnatus	Hygromiidae
Orthalicus princeps	Orthalicidae
Otala lactea	Helicidae
Otala punctata	Helicidae
Otala sp.	Helicidae
Oxychilus alliarius	Oxychilidae
Oxychilus cellarius	Oxychilidae
Oxychilus draparnaudi	Oxychilidae
Oxychilus sp.	Oxychilidae
Papillifera papillaris	Clausiliidae
Paralaoma servilis	Punctidae
Phenacolimax major	Vitrinidae
Polygyra cereolus	Polygyridae
Pomacea canaliculata	Ampullariidae
Praticolella griseola	Polygyridae
Prietocella barbara	Cochlicellidae
Pupillidae, species	
Rumina decollata	Subulinidae
Stylommatophora, species	
Subulina sp.	Subulinidae
Succinea costaricana	Succineidae
Succinea horticola	Succineidae
Succinea putris	Succineidae
Succinea sp.	Succineidae
Theba pisana	Helicidae
Trochoidea cretica	Hygromiidae
Trochoidea elegans	Hygromiidae
Trochoidea pyramidata	Hygromiidae
Trochoidea sp.	Hygromiidae
Trochoidea trochoides	Hygromiidae
Trochulus hispidus	Hygromiidae
Trochulus sp.	Hygromiidae
Trochulus striolatus	Hygromiidae
Truncatellina cylindrica	Pupillidae
Vallonia costata	Valloniidae
Vallonia pulchella	Valloniidae

Pest	Family
Vertiginidae, species	
Vitrinidae, species	
Xerolenta obvia	Hygromiidae
Xeropicta derbentina	Hygromiidae
Xeropicta protea	Hygromiidae
Xeropicta sp.	Hygromiidae
Xerosecta cespitum	Hygromiidae
Xerotricha conspurcata	Hygromiidae
Zonitidae, species	
Zonitoides arboreus	Gastrodontidae
Nematodes	
Rhabditidae, species	
Weeds	
Agropyron sp.	Poaceae
Ailanthus altissima	Simaroubaceae
Asclepias sp.	Asclepiadaceae
Asphodelus fistulosus	Liliaceae
Asteraceae, species	
Avena ludoviciana	Poaceae
Avena sterilis	Poaceae
Azolla pinnata	Azollaceae
Betula sp.	Betulaceae
Bignoniaceae, species	
Boraginaceae, species	
Brassica sp.	Brassicaceae
Capsicum annuum	Solanaceae
Cenchrus sp.	Poaceae
Centaurea sp.	Asteraceae
Chloris sp.	Poaceae
Clematis sp.	Ranunculaceae
Cordia sp.	Boraginaceae
Cynodon dactylon	Poaceae
Digitaria sanguinalis	Poaceae
Echinochloa sp.	Poaceae
Eleusine coracana	Poaceae
Eleusine indica	Poaceae
Eleusine sp.	Poaceae
Eucalyptus sp.	Myrtaceae
Galium sp.	Rubiaceae
Gossypium sp.	Malvaceae
Hordeum jubatum	Poaceae

Pest	Family
Hordeum murinum	Poaceae
Hordeum sp.	Poaceae
Hordeum vulgare	Poaceae
Hypochaeris sp.	Asteraceae
Imperata cylindrica	Poaceae
Ipomoea aquatica	Convolvulaceae
Juniperus sp.	Cupressaceae
Lactuca sativa	Asteraceae
Lens culinaris	Fabaceae
Lens sp.	Fabaceae
Ligustrum sp.	Oleaceae
Linum usitatissimum	Linaceae
Magnoliophyta, sp.	
Malvaceae, species	
Miscanthus sinensis	Poaceae
Miscanthus sp.	Poaceae
Nassella trichotoma	Poaceae
Not a	
Oryza sativa	Poaceae
Oryza sp.	Poaceae
Pennisetum glaucum	Poaceae
Pennisetum polystachion	Poaceae
Phalaris canariensis	Poaceae
Phragmites australis	Poaceae
Phragmites sp.	Poaceae
Picris echioides	Asteraceae
Pinus sp.	Pinaceae
Platanus sp.	Platanaceae
Poa sp.	Poaceae
Poaceae, species	
Populus sp.	Salicaceae
Prunus sp.	Rosaceae
Quercus sp.	Fagaceae
Rutaceae, species	
Saccharum sp.	Poaceae
Saccharum spontaneum	Poaceae
Salicaceae, species	
Salix sp.	Salicaceae
Sesamum indicum	Pedaliaceae
Setaria sp.	Poaceae
Solanum sp.	Solanaceae
Sonchus arvensis	Asteraceae
Sonchus oleraceus	Asteraceae

Pest	Family
Sorghum bicolor	Poaceae
Sorghum sp.	Poaceae
Taraxacum officinale	Asteraceae
Taraxacum sp.	Asteraceae
Thymelaea sp.	Thymelaeaceae
Thysanolaena latifolia	Poaceae
Tilia sp.	Tiliaceae
Tridax procumbens	Asteraceae
Triticum aestivum	Poaceae
Triticum sp.	Poaceae
Ulmus sp.	Ulmaceae
Xylopia aethiopica	Annonaceae
Zea mays	Poaceae

Table 6.5 Examples of insects with potential to be introduced into one or more countries of the Greater Caribbean Region on or in wood packaging material (adapted from: (Culliney *et al.*, 2007)).

Order: Family	Species	Distribution[1]	References
Coleoptera: Bostrichidae	*Heterobostrychus brunneus*	sub-Saharan Africa, United States (CA)	(Pasek, 2000, Haack, 2006, Schabel, 2006)
	Sinoxylon anale	Australia, Brazil, China, India, Indonesia, New Zealand, Philippines, Saudi Arabia, Southeast Asia, Sri Lanka, United States (CA, FL, MI, NY, OH, PA), Venezuela	(Pasek, 2000, Teixera *et al.*, 2002)
	Sinoxylon crassum	East Africa, India, Pakistan, Southeast Asia	(Singh and Bhandari, 1987, Singh Rathore, 1995, Gul and Bajwa, 1997, Pasek, 2000, Walker, 2006)
	Xylothrips flavipes	Greece, Madagascar, North Africa, Southeast Asia	(Lesne, 1900, Pasek, 2000, Nardi, 2004)
Coleoptera: Buprestidae	*Buprestis haemorrhoidalis*	Canary Islands, Europe, Kazakhstan	(Pasek, 2000, Löbl and Smetana, 2006)
	Melanophila cuspidata	North Africa, Southern Europe	(Pasek, 2000, Kubán, 2004)
Coleoptera: Cerambycidae	*Callidiellum rufipenne*	China, Italy, Japan, Korea, Russia, Spain, Taiwan, United States (CT, NC, WA)	(Hoebeke, 1999, Pasek, 2000)
	Monochamus alternatus	China, Japan, Korea, Laos, Taiwan, Vietnam	(Pasek, 2000, Kawai *et al.*, 2006)
	Plagionotus christophi	Japan, Korea, Northeastern China, Southeastern Central Asia	(Cherepanov, 1988, Pasek, 2000, KFS, 2004)
	Pyrrhidium sanguineum	Europe, North Africa, West Asia	(Pasek, 2000, Hoskovec and Rejzek, 2006)
	Stromatium barbatum	Bangladesh, Burma, East Africa, India, Pakistan	(CAB, 1985, Pasek, 2000)
	Xylotrechus grayi	China, Japan, Korea, Taiwan	(Pasek, 2000, Hua, 2002)
	Xylotrechus magnicollis	Burma, China, India, Laos, Russia, Taiwan	(Pasek, 2000, Hua, 2002)
Coleoptera: Curculionidae	*Pissodes pini*	Russia, Western Europe	(Kulinich and Orlinskii, 1998, Pasek, 2000)
Coleoptera: Curculionidae: Scolytinae	*Carphoborus minimus*	Italy, Spain, Turkey	(Haack, 2001)
	Carphoborus pini	Italy, Spain	(Haack, 2001)
	Coccotrypes advena	Cuba; Old World Tropics; Suriname; (United States (FL)	(Bright and Torres, 2006)
	Cryphalus asperatus	Germany, Italy	(Haack, 2001)
	Cryphalus piceae	France, Italy	(Haack, 2001)
	Crypturgus cinereus	Australia, Belgium, Germany, Russia, Spain	(Haack, 2001)
	Crypturgus mediterraneus	France, Italy, Netherlands, Portugal, Spain	(Haack, 2001)
	Crypturgus numidicus	Estonia, Greece, Latvia,	(Haack, 2001)

Order: Family	Species	Distribution[1]	References
		Spain	
	Dryocoetes autographus	Belgium, Brazil, Germany, Italy, Russia	(Haack, 2001)
	Dryocoetes villosus	Belgium, France, Germany, Italy, United Kingdom	(Haack, 2001)
	Euwallacea validus	Burma, China, Costa Rica, Japan, Korea, Malaysia, Philippines, United States (LA, MD, NY, PA), Vietnam	(Pasek, 2000, Haack, 2001, Cognato, 2004)
	Gnathotrichus materiarius	Dominican Republic, United States (OR, SD), Western Europe	(Mudge *et al.*, 2001)
	Hylastes angustatus	Belgium, France	(Haack, 2001)
	Hylastes ater	Chile, France, Germany, Italy, Spain	(Haack, 2001)
	Hylastes attenuatus	France, Italy, Portugal, South Africa, Spain	(Haack, 2001)
	Hylastes cunicularius	Belgium, Germany, Italy, Spain	(Haack, 2001)
	Hylastes linearis	Italy, Portugal, Spain	(Haack, 2001)
	Hylastes opacus	Brazil, Canada, Russia, United States (ME, NH, NY, OR, WV)	(Haack, 2001, Mudge *et al.*, 2001, Haack, 2006)
	Hylesinus varius	Belgium, Italy, United Kingdom	(Haack, 2001)
	Hylurgops glabratus	Italy	(Haack, 2001)
	Hylurgops palliatus	Belgium, Germany, Italy, Spain, United Kingdom, United States (PA)	(Haack, 2001, 2006)
	Hylurgus ligniperda	Chile, France, Italy, Portugal, Spain, United States (NY)	(Haack, 2001, 2006)
	Ips acuminatus	China, France, Italy, Russia, Spain	(Haack, 2001)
	Ips amitinus	Finland, Italy	(Haack, 2001)
	Ips cembrae	Belgium, China, Germany, Italy	(Haack, 2001)
	Ips mannsfeldi	Spain, Turkey	(Haack, 2001)
	Ips sexdentatus	Belgium, France, Italy, Portugal, Spain	(Haack, 2001)
	Ips typographus	Belgium, France, Germany, Italy, Russia	(Haack, 2001)
	Orthotomicus erosus	China, Mediterranean Region, United States (CA), West and Central Asia	(Lee *et al.*, 2005)
	Orthotomicus laricis	France, Germany, Italy, Russia, Spain	(Haack, 2001)
	Orthotomicus proximus	Finland, Italy	(Haack, 2001)
	Orthotomicus suturalis	Estonia, France, Germany, United Kingdom	(Haack, 2001)
	Phloeosinus rudis	Belgium, Japan	(Haack, 2001)

Order: Family	Species	Distribution[1]	References
	Phloeotribus scarabaeoides	Asia, Mediterranean Region, Southern Europe	(Pasek, 2000, Rodríguez *et al.*, 2003)
	Pityogenes bidentatus	France, Germany, Italy, Portugal, Spain, United States (NY)	(Haack, 2001, 2006)
	Pityogenes bistridentatus	France, Italy, Spain, Turkey, United Kingdom	(Haack, 2001)
	Pityogenes calcaratus	France, Italy, Spain	(Haack, 2001)
	Pityogenes chalcographus	Belgium, Germany, Italy, Russia, Spain	(Haack, 2001)
	Pityogenes quadridens	Finland, Lithuania, Portugal, Spain, Turkey	(Haack, 2001)
	Pityogenes trepanatus	Lithuania	(Haack, 2001)
	Pityokteines curvidens	France, Greece, Italy	(Haack, 2001)
	Pityokteines spinidens	Austria, France, Germany, Italy, Russia	(Haack, 2001)
	Pityophthorus pityographus	France, Germany, Italy, Netherlands	(Haack, 2001)
	Polygraphus poligraphus	Belgium, Germany, Italy, Russia, United Kingdom	(Haack, 2001)
	Polygraphus subopacus	Azerbaijan, Italy	(Haack, 2001)
	Pteleobius vittatus	Italy	(Haack, 2001)
	Scolytus intricatus	Belgium, France, Germany, Italy	(Haack, 2001)
	Scolytus ratzeburgi	Finland, Russia, Ukraine	(Haack, 2001)
	Scolytus scolytus	United Kingdom	(Haack, 2001)
	Taphrorychus bicolor	Belgium, Finland, France, Germany, Netherlands	(Haack, 2001)
	Taphrorychus villifrons	Belgium, France, Germany, Latvia, Turkey	(Haack, 2001)
	Tomicus minor	Brazil, Italy, New Zealand, Turkey	(Haack, 2001)
	Tomicus piniperda	Belgium, France, Italy, Spain, United Kingdom, United States (OH)	(Haack, 2001, 2006)
	Trypodendron domesticum	Italy, Turkey	(Haack, 2001)
	Trypodendron signatum	Belgium, France, Germany, Netherlands	(Haack, 2001)
	Xyleborinus alni	Austria, Czechoslovakia, Germany, Japan, Poland, Russia, United States (OR, WA)	(Mudge *et al.*, 2001)
	Xyleborus californicus	Canada, Russia, United States (AR, CA, DE, MD, OR, SC)	(Mudge *et al.*, 2001)
	Xyleborus eurygraphus	North Africa, Southern and Western Europe, Turkey	(Haack, 2001, Cognato, 2004)
	Xyleborus glabratus	India, Japan, Taiwan, United States (SC, GA, FL)	(Fraedrich *et al.*, 2008)
	Xyleborus pfeili	Africa, Asia, Europe, New Zealand, United States (MD, OR)	(Mudge *et al.*, 2001)

Order: Family	Species	Distribution[1]	References
	Xyleborus similis	Africa, Asia, Australia, Micronesia, United States (TX)	(Wood, 1960, Rabaglia *et al.*, 2006)
	Xylechinus pilosus	Europe	(Haack, 2001, Alonso-Zarazaga, 2004)
	Xylosandrus morigerus	Throughout world; in Caribbean only Puerto Rico	(Bright and Torres, 2006)
	Xyloterinus politus	Canada, United States (WA)	(Mudge *et al.*, 2001)
Hymenoptera: Siricidae	*Sirex noctilio*	Australia, Italy, New Zealand, South Africa, Spain, United States (NY)	(Hoebeke *et al.*, 2005)
Hymenoptera: Xiphydriidae	*Xiphydria prolongata*	Russia, United States (MI, NJ, OR), Western Europe	(Mudge *et al.*, 2001)
Isoptera: Rhinotermitidae	*Coptotermes crassus*	Mexico, Central America	(Constantino, 1998, Pasek, 2000)

[1] State abbreviations: AR = Arkansas, CA = California, CT = Connecticut, DE = Delaware, FL = Florida, LA = Louisiana, MD = Maryland, ME = Maine, MI = Michigan, NC = North Carolina, NH = New Hampshire, NJ = New Jersey, NY = New York, OH = Ohio, OR = Oregon, PA = Pennsylvania, SC = South Carolina, SD = South Dakota, TX = Texas, WA = Washington, WV = West Virginia

Figure 7.1 Potential for contamination during timber extraction process.

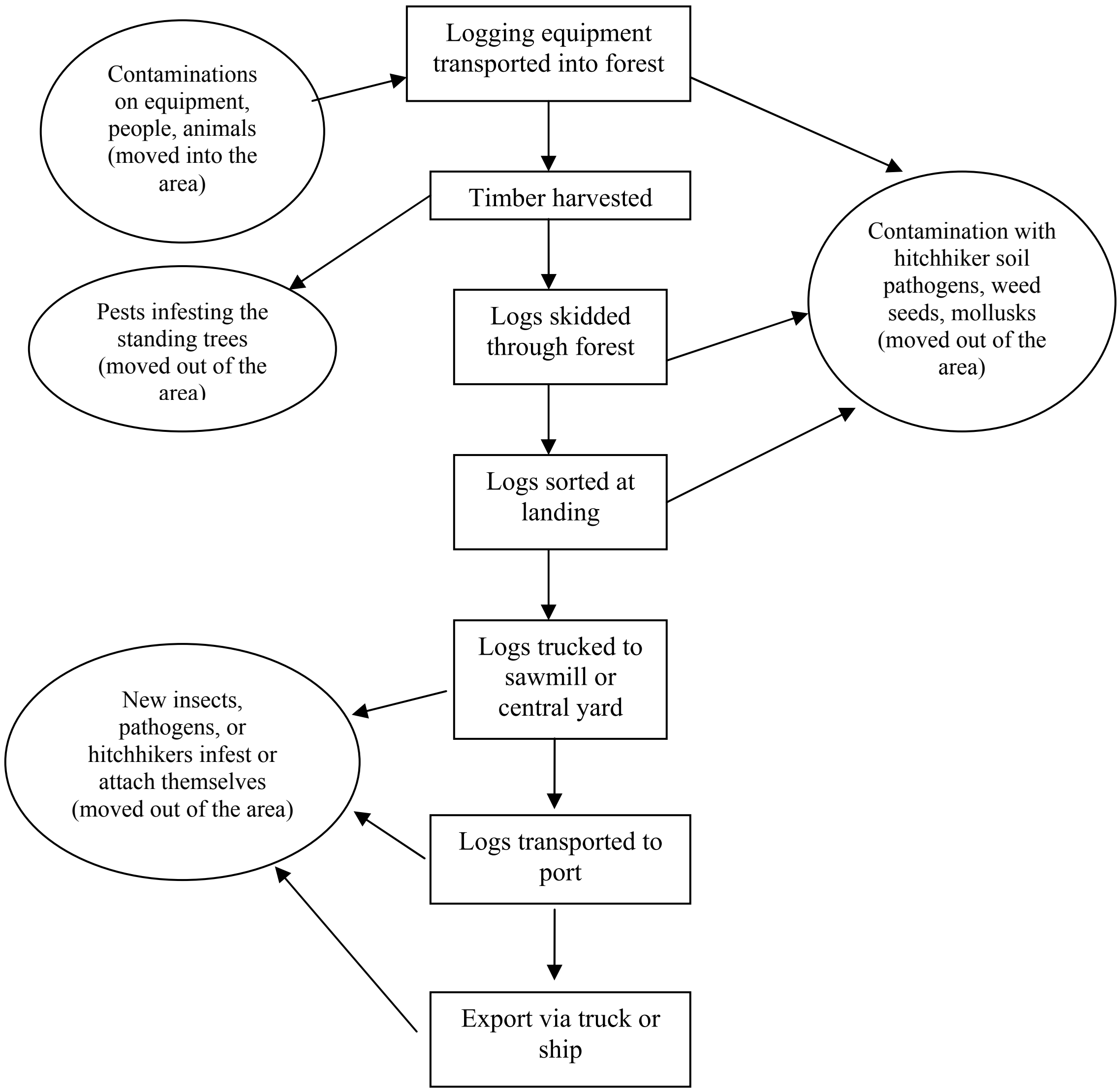


Table 7.1 Extent of forest land in the Greater Caribbean Region and changes in extent of forest land over recent years. Data sources: (FAO, 2005b, USDA-FS, 2008).

Area/Country	*Extent of forest land*			*Changes (1997-2007)*	
	Total land area	*Forest*		*Forest area*	
		Area	*Percent of total land area*	*10-year change*	*Change in forested land*
	1,000 ha		*%*	*1,000 ha*	
Florida	14,175	6,535	46.1	-43	-0.7%
Alabama	13,126	9,184	70.0	295	3.2%
Louisiana	11,283	5,755	51.0	178	3.1%
Mississippi	12,151	7,941	65.4	416	5.2%
Texas	67,864	6,990	10.3	-437	-6.3%
Total Gulf States	**118,600**	**36,405**	**30.7**	**407**	1.1%

Area/Country	*Extent of forest land*			*Changes (2000-2005)*	
	Total land area	*Forest*		*Forest area*	
		Area	*Percent of total land area*	*5-year change*	*Change in forested land*
	1,000 ha		*%*	*1,000 ha*	
Anguilla	8	6	71.4	0	0.0%
Antigua and Barbuda	44	9	21.4	0	0.0%
Aruba	19	0.42	2.2	0	0.0%
Bahamas	1,388	515	51.5	0	0.0%
Barbados	43	2	4	0	0.0%
Bermuda	5	1	20	0	0.0%
British Virgin Islands	15	4	24.4	0	0.0%
Cayman Islands	26	12	48.4	0	0.0%
Cuba	11,086	2,713	24.7	278	10.2%
Dominica	75	46	61.3	-1	-2.2%
Dominican Republic	4,873	1,376	28.4	0	0.0%
Grenada	34	4	12.2	0	0.0%
Guadeloupe	171	80	47.2	-1	-1.3%
Haiti	2,775	105	3.8	-4	-3.8%
Jamaica	1,099	339	31.3	-2	-0.6%
Martinique	110	46	43.9	0	0.0%
Montserrat	10	4	35	0	0.0%
Netherlands Antilles	80	1	1.5	0	0.0%
Puerto Rico	895	408	46	1	0.2%
Saint Kitts and Nevis	36	5	14.7	0	0.0%
Saint Lucia	62	17	27.9	0	0.0%
Saint Vincent and the Grenadines	39	11	27.4	1	9.1%
Trinidad and Tobago	513	226	44.1	-2	-0.9%
Turks and Caicos Islands	43	34	80	0	0.0%
United States Virgin Islands	34	10	27.9	0	0.0%
Total Caribbean Islands	**23,482**	**5,974**	**26.1**	**268**	4.5%

Area/Country	*Extent of forest land*			*Changes (2000-2005)*	
	Total land area	*Forest*		*Forest area*	
		Area	*Percent of total land area*	*5-year change*	*Change in forested land*
Belize	2,296	1,653	72.5	0	0.0%
Costa Rica	5,110	2,391	46.8	15	0.6%
El Salvador	2,104	298	14.4	-26	-8.7%
Guatemala	10,889	3,938	36.3	-270	-6.9%
Honduras	11,209	4,648	41.5	-782	-16.8%
Nicaragua	13,000	5,189	42.7	-350	-6.7%
Panama	7,552	4,294	57.7	-13	-0.3%
Total Central America	**52,160**	**22,411**	**43.9**	**-1,426**	-6.4%
Guyana	21,497	15,104	76.7	0	0.0%
Suriname	16,327	14,776	94.7	0	0.0%
Total South America (Car.)	**37,824**	**29,880**	**79.0**	**0**	0.0%
Total Greater Caribbean Region	**232,066**	**94,670**	**40.8**	**-751**	-0.8%

Table 7.2 Imports of raw wood products from the world into the Greater Caribbean Region (2006; excluding U.S. Gulf States. Data source: (UNComtrade, 2008).

Importing Countries	**Logs/Poles**		**Poles, Piles (pointed)**		**Railway ties (not treated)**	**Fuelwood**	**Total Imports**
	Conifer	**Non-conifer**	**Conifer**	**Non-conifer**			
	metric tons						
Caribbean Islands	2,290.7	2,079.2	4,013.7	1,226.4	784.8	1,614.9	12,009.7
Central America	793.5	700.5	821.9	99.2	--	1,681.4	4,096.5
Guyana/Suriname	--	24.5	24.9	0.1	--	0.0	49.5
Total	**3,084.2**	**2,804.2**	**4,860.5**	**1,325.7**	**784.8**	**3,296.3**	**16,155.7**

Table 7.3 Raw wood products trade within the Greater Caribbean Region (2006): total imports reported (in metric tons). Data source: (UNComtrade, 2008).

Importing Countries	**Exporting Countries**			
	Caribbean Islands	**Central America**	**Guyana/ Suriname**	**U.S.**[1]
	metric tons			
Caribbean Islands	42.9	--	1,661.0	9,676.2
Central America	--	1,703.0	--	1,830.5
Guyana/Suriname	--	--	--	24.7

[1] Entire United States

Table 7.4 Relative quantities of raw wood products traded among countries of the Greater Caribbean Region: reported imports, 2006. Data source: (UNComtrade, 2008).

Importing Countries		Exporting Countries: Dominican Republic	Jamaica	Trinidad-Tobago	Belize	Costa Rica	El Salvador	Guatemala	Honduras	Nicaragua	Panama	Guyana	Suriname	U.S.
Caribbean Islands	Bahamas													5,000-10,000
	Barbados			< 100								100-500		500-1,000
	Dominica											500-1,000		100-500
	Grenada											< 100		100-500
	Jamaica											100-500		1,000-5,000
	St Kitts-Nevis			< 100										100-500
	St Lucia													< 100
	St Vincent-Gren											< 100	< 100	100-500
	Trinidad-Tobago											500-1,000		1,000-5,000
Central America	Belize													< 100
	Costa Rica							< 100			100-500			
	El Salvador							< 100	< 100	100-500				
	Guatemala					< 100	< 100		< 100	< 100				< 100
	Honduras						< 100			100-500				1,000-5,000
	Nicaragua								< 100					
	Panama					100-500	< 100							< 100
	Suriname													< 100
	United States	< 100	< 100	500-1,000		< 100		< 100	1,000-5,000			100-500		

Key (metric tonnes)

- < 100
- 100-500
- 500-1,000
- 1,000-5,000
- 5,000-10,000

Table 7.5 Exports of raw wood products from the Caribbean into the world (2006). Data source: (UNComtrade, 2008, USCB, 2008).

Exporting Countries	Logs/Poles		Poles, Piles (pointed)		Railway ties	Fuelwood	Total Exports
	Conifer	Non-conifer	Conifer	Non-conifer	(not treated)		
	metric tons						
Caribbean Islands	9.6	33.5	0.04	3.0	--	1.9	48.0
Central America	10,872.6	123,260.8	18,711.7	1,216.3	--	3,265.6	157,327.0
Guyana/Suriname	6.6	73,961.2	5,351.4	21,323.5	--	31.5	100,674.2
U.S. Gulf States[1]	13,150.4	4,385.4	7,607.3	426.6	273.4	9,724.7	35,567.8
TOTAL	24,039.2	201,640.9	31,670.44	22,969.4	273.4	13,023.7	293,617.0

[1] Exports to Greater Caribbean Region only.

Table 7.6 Raw wood products trade within the Greater Caribbean Region (2006): total exports reported (in metric tons). Data source: (UNComtrade, 2008, USCB, 2008).

Exporting Countries	Importing Countries			
	Caribbean Islands	Central America	Guyana/ Suriname	U.S.[1]
	metric tons			
Caribbean Islands	20.4	--	0.3	--
Central America	1,078.5	3,045.4	--	21,501.1
Guyana/Suriname	3,394.6	67.3	--	52,950.1
U.S. Gulf States	33,459.0	2,079.7	29.1	--

[1] Entire United States.

Table 7.7 Relative frequency of raw wood products traded among countries of the Greater Caribbean Region: reported exports (2006). Data sources: (UNComtrade, 2008, USCB, 2008)

	Exporting Countries	Importing Countries																														
		Caribbean Islands																					Central America							S.A.		
		Anguilla	Antigua-Barbuda	Aruba	Bahamas	Barbados	Bermuda	British Virgin Islands	Cayman Islands	Cuba	Dominica	Dominican Republic	Guadeloupe	Grenada	Haiti	Jamaica	Netherlands Antilles	St .Kitts-Nevis	St. Lucia	St. Vincent-Grenadines	Trinidad-Tobago	Turks-Caicos Islands	Belize	Costa Rica	El Salvador	Guatemala	Honduras	Nicaragua	Panama	Guyana	Suriname	U.S.
Car	Trinidad-Tobago		•																	•												
Central America	Belize																															●
	Costa Rica																									•	•		●			•
	El Salvador																									•						
	Guatemala																								•							
	Honduras					●						•			•	•							•		•			•	●			⬤
	Nicaragua											•													●	•	●		●			
	Panama											●												●								●
S.A.	Guyana	•	•		●	●					●	●		•			•		•	●	●								•			⬤
Gulf States	Alabama					•			●	⬤		●			•	●			•				●									
	Florida	●	●	●	⬤	●	•	●	●	●	●	•	•	●	●	●		●	●	●	●	●	•	●		●	•		●	•		
	Louisiana															●					•											
	Mississippi											●											•			●						
	Texas																				•		●									

Key (metric tonnes)

•	1 - 100
•	100 - 500
●	500 - 1,000
●	1,000 - 5,000
●	5,000 - 10,000
●	10,000 - 50,000
⬤	> 50,000

Table 7.8 Examples of invasive trees established in the Greater Caribbean Region.

Species	Native	Uses	Naturalized or Invasive	References
Acacia farnesiana (Fabaceae)	American Tropics	Agroforestry	Bahamas; Puerto Rico	(Kairo *et al.*, 2003, ISSG, 2008)
Acacia mangium (Fabaceae)	Australia; Indonesia; New Guinea	Agroforestry; ecological restoration	Dominican Republic; Puerto Rico	(Kairo *et al.*, 2003)
Acacia nilotica (Fabaceae)	Africa; Indian subcontinent	browse; firewood; timber; tannins; medicinal	Anguilla; Antigua and Barbuda; Puerto Rico	(Binggeli *et al.*, 1998, Kairo *et al.*, 2003, ISSG, 2008)
Adenanthera pavonina (Fabaceae)	India; Malaysia		Most Caribbean islands; Guyana	(ISSG, 2008)
Albizia julibrissin (Fabaceae)	Iran to Japan	Reclamation; ornamental	U.S. (Florida)	(Langeland and Stocker, 2001)
Casuarina equisetifolia (Casuarinaceae)	Asia; Australia	firewood; charcoal; coastal reclamation; medicinal; tannins; dyes; pulp; timber	Bahamas; Dominican Republic; Jamaica; Puerto Rico; U.S. (Florida)	(Binggeli *et al.*, 1998, Langeland and Stocker, 2001, Kairo *et al.*, 2003)
Eucalyptus robusta (Myrtaceae)	Australia	Agroforestry; plantations	Puerto Rico	(Kairo *et al.*, 2003)
Leucanea leucocephala (Fabaceae)	Central America; Mexico	Reforestation; windbreaks; firebreaks; crafts	Bahamas; Dominican Republic; Haiti; Jamaica; Puerto Rico; U.S. (Florida, Texas)	(Binggeli *et al.*, 1998, Kairo *et al.*, 2003, ISSG, 2008)
Melaleuca quinquenervia (Myrtaceae)	Australia; Irian Jaya; Papua New Guinea	Windbreaks; bark used as fruit packing material and torches; agroforestry	Bahamas; Dominican Republic; Puerto Rico; throughout West Indies; U.S. (Florida)	(Binggeli *et al.*, 1998, Langeland and Stocker, 2001, Kairo *et al.*, 2003, Lugo, 2004)
Melia azedarach (Meliaceae)	Asia; Australia	Reforestation	U.S. (Florida)	(Langeland and Stocker, 2001)
Mimosa pigra (Fabaceae)	Tropical America	Erosion control; ornamental	U.S. (Florida)	(ISSG, 2008)
Parkinsonia aculeate (Fabaceae)	Central America; Mexico; South America; southwestern U.S.	Agroforestry	Dominican Republic; Puerto Rico	(Richardson, 1998, Kairo *et al.*, 2003)
Pinus caribaea (Pinaceae)	Central America	Plantations	Dominican Republic; Puerto Rico	(Richardson, 1998, Kairo *et al.*, 2003)
Psidium guajava (Myrtaceae)	American tropics	Agroforestry	Bahamas; Puerto Rico	(Richardson, 1998, Kairo *et al.*, 2003)
Sapium sebiferum (Euphorbiaceae)	Eastern Asia	Ornamental	U.S. (Alabama; Florida; Louisiana; Mississippi; Texas)	(Langeland and Stocker, 2001)

Schinus terebinthifolius (Anacardiaceae)	South America	Ornamental	Bahamas; U.S. (Florida)	(Langeland and Stocker, 2001)
Spathodea campanulata (Bignoniaceae)	West Africa	Ornamental	Puerto Rico	(Lugo, 2004)
Tamarix spp. (Tamaricaceae)	Southern Europe to Asia	Erosion control; ornamental	Texas	(Langeland and Stocker, 2001, ISSG, 2008)
Ziziphus mauritiana (Rhamnaceae)	Central Asia	Agroforestry; timber	Barbados; Guadeloupe; Jamaica; Martinique	(Kairo *et al.*, 2003, ISSG, 2008)

Table 8.1 Imports of "bulbs, tubers, tuberous roots, corms, crowns and rhizomes" [in plant units] into countries of the Greater Caribbean Region in 2007. Data source: (UNComtrade, 2008). *Note:* The United States is not listed as an importing country, because data could not be restricted to the Gulf States.

	Importing country								
Trading partner	**Bahamas**	**Barbados**	**Colombia**	**El Salvador**	**Guatemala**	**Honduras**	**Jamaica**	**Trinidad and Tobago**	**Total**
Canada		1			712,258				**712,259**
Germany							40		**40**
Israel			421,828						**421,828**
Italy			978,482						**978,482**
Netherlands		360	14,119,729	7,506	14,146				**14,141,741**
Peru					87,160				**87,160**
South Africa		505							**505**
Thailand		10					0	1	**11**
USA	88,221		0	48,138	73,288	1,198	199,025	7,901	**417,771**
World Total	**88,221**	**876**	**15,520,039**	**55,644**	**886,851**	**1,198**	**199,065**	**7,902**	**16,759,796**

Table 8.2 Imports of "live plants (not otherwise specified) including their roots; mushroom spawn" [in plant units] into countries of the Greater Caribbean Region in 2007. Data source: (UNComtrade, 2008). *Note:* The United States is not listed as an importing country, because data could not be restricted to the Gulf States.

	Importing country											
Trading partner	**Bahamas**	**Barbados**	**Belize**	**Colombia**	**El Salvador**	**Guatemala**	**Honduras**	**Jamaica**	**Nicaragua**	**Panama**	**Trinidad and Tobago**	**Total**
Brazil				1		79						**80**
Canada		3,236										**3,236**
China				30,003	200	20,000		204				**50,203**
Colombia			680			1,218				199		**1,898**
Costa Rica		2,467		205	1,762	12,514	247		117,373	7,223	580	**16,948**
Denmark		2,224										**2,224**
Ecuador				1,924								**1,924**
El Salvador						2,250						**2,250**
Germany		4,359										**4,359**
Guatemala					310,689				2,245			**310,689**
Honduras			1,298									**1,298**
Iceland				90								**90**
India		381		987								**1,368**
Israel				14,155				626				**14,155**
Italy				170								**170**
Jamaica		72										**72**
Japan				114								**114**
Mexico			2,291									**2,291**
Namibia		310										**310**
Netherlands		74,469		75,926		2,911		163			1,045	**153,306**
Other Asia				837	205	290		720		180		**1,332**
Spain				696								**696**
Thailand		2,097				820		7,159		1,015	1,435	**2,917**
U.K.		97		2								**99**
USA	3,913,508	12,613		228,567	2,443	4,313	382	9,186		2,780	6,554	**4,161,444**
World	**3,913,508**	**102,325**	**4,269**	**353,753**	**315,299**	**44,395**	**629**	**18,059**	**119,618**	**11,397**	**9,614**	**4,733,549**

Table 8.3 Imports of “trees, shrubs and bushes, of kinds which bear edible fruit or nuts” [in plant units] into countries of the Greater Caribbean Region in 2007. Data source: (UNComtrade, 2008). *Note:* The United States is not listed as an importing country, because data could not be restricted to the Gulf States.

	Importing country							
Trading partner	**Bahamas**	**Colombia**	**El Salvador**	**Guatemala**	**Honduras**	**Nicaragua**	**Panama**	**Total**
Argentina		104,080						**104,080**
Canada	1,543							**1,543**
Chile		98,074						**98,074**
Colombia							380	**380**
Costa Rica				117,535	63,693	5,944		**187,172**
El Salvador				15,709				**15,709**
Guatemala			109,703		65,451	14,728		**189,882**
Honduras		62,616	887	167,733				**231,236**
Israel		380,231						**380,231**
Japan		1,047		1,639				**2,686**
Mexico				48,791	91,730	1,870		**142,391**
Netherlands				64,785				**64,785**
Peru							11,078	**11,078**
USA	310,489	169,777	4,176	11,867	7,857			**504,166**
Venezuela						356		**356**
World	**312,032**	**815,824**	**114,767**	**428,059**	**228,732**	**22,897**	**11,458**	**1,933,769**

Table 8.4 Imports of “roses, including their roots” [in plant units] into countries of the Greater Caribbean Region in 2007. Data source: (UNComtrade, 2008). *Note:* The United States is not listed as an importing country, because data could not be restricted to the Gulf States.

	Importing country							
Trading partner	**Bahamas**	**Barbados**	**Colombia**	**El Salvador**	**Guatemala**	**Jamaica**	**Panama**	**Grand Total**
Belgium		384						**384**
Colombia					24,765			**24,765**
Ecuador			465,499					**465,499**
France			2,106					**2,106**
Germany			177					**177**
Guatemala				99,501				**99,501**
Italy			7,180					**7,180**
Netherlands			23,158		1,205			**24,363**
New Zealand			352					**352**
Spain			262					**262**
United Kingdom			170					**170**
USA	3,477	250			4,060	10,892	189	**18,868**
World	**3,477**	**634**	**498,905**	**99,501**	**30,031**	**10,892**	**189**	**643,629**

Table 8.5 Imports of “azaleas and rhododendrons, including their roots” [in plant units] into countries of the Greater Caribbean Region in 2007. Data source: (UNComtrade, 2008). *Note:* The United States is not listed as an importing country, because data could not be restricted to the Gulf States.

	Importing country		
Trading partner	**Bahamas**	**El Salvador**	**Total**
Guatemala		3,557	3,557
USA	2,754		2,754
World	2,754	3,557	6,311

Table 8.6 Imports of “unrooted cuttings and slips” [in plant units] into countries of the Greater Caribbean Region in 2007. Data source: (UNComtrade, 2008). *Note:* The United States is not listed as an importing country, because data could not be restricted to the Gulf States.

	Importing country		
Trading partner	**Bahamas**	**Trinidad and Tobago**	**Total**
USA	237,875	90	**237,965**

Table 8.7 Number of shipments[1] of propagative material imported into the United States from countries in the Greater Caribbean Region in 2007. Data source: (USDA, 2008e).

Country of origin	Number of shipments
Bahamas	2
Belize	75
Colombia	339
Costa Rica	614
Dominica	8
Dominican Republic	99
El Salvador	37
Guatemala	385
Guyana	4
Haiti	1
Honduras	31

Country of origin	Number of shipments
Jamaica	36
Martinique	2
Netherland Antilles	3
Nicaragua	1
Panama	121
Puerto Rico	4
St. Maartin	1
Suriname	61
Trinidad and Tobago	8
Venezuela	67

[1]Note: the quantity of propagative material included in a shipment varies

Table 8.8 Reportable pests intercepted at U.S. ports of entry on shipments of propagative material from countries in the Greater Caribbean Region in 2007. Data source: (USDA, 2008d).

Commodity	Pest type	Pest name (family) [origin of shipment]
Aechmea sp.	Insect	*Idiarthron* sp. (Tettigoniidae) [Costa Rica]
Aglaonema sp.	Disease	*Leptosphaeria* sp. (Leptosphaeriaceae) [Costa Rica]
	Insect	*Ceroplastes* sp. (Coccidae), Pentatomoidea and Pseudococcidae [Costa Rica]
	Mollusk	*Succinea costaricana* (Succineidae) [Costa Rica]
Ajuga reptans	Insect	Aleyrodidae [Costa Rica]
Ajuga sp.	Insect	Aleyrodidae and Noctuidae [Costa Rica]
	Mite	Acari [Costa Rica]
Alpinia sp.	Insect	Pseudococcidae [Costa Rica]
Alstroemeria sp.	Insect	*Copitarsia* sp. (Noctuidae) [Colombia]
Anacardium occidentale	Insect	*Hypothenemus* sp. (Curculionidae: Scolytinae) [Dominican Republic]
Aralia sp.	Insect	Pseudococcidae [El Salvador]
	Mite	Tetranychidae [El Salvador]
Armeria sp.	Disease	*Alternaria* sp. (Hyphomycetes) [Colombia]
Aster sp.	Insect	*Frankliniella* sp. (Thripidae) [Colombia]
Bacopa sp.	Insect	Aleyrodidae [Costa Rica]
Bouquet	Insect	Agromyzidae [Colombia] and Tettigoniidae [Costa Rica]
Chrysalidocarpus sp.	Insect	*Coccotrypes* sp. (Curculionidae: Scolytinae) [Costa Rica]
Chrysanthemum sp.	Insect	Agromyzidae, *Copitarsia* sp. (Noctuidae) [Colombia]
Cleome sp.	Insect	Aleyrodidae [Costa Rica]
Cocos nucifera	Insect	Tineidae [Costa Rica]
Codiaeum sp.	Insect	*Blapstinus* sp. (Tenebrionidae), *Frankliniella* sp., *Thrips palmi* (Thripidae), *Leucania* sp. (Noctuidae), *Philephedra* sp. (Coccidae), *Phyllophaga* sp. (Scarabaeidae), Aleyrodidae, Cicadellidae, Coccidae, Coccoidea, Gryllidae, Noctuidae, Pentatomidae, and Pseudococcidae [Costa Rica], *Leucothrips* sp. (Thripidae) [Costa Rica, Dominican Republic, El Salvador], Thripidae [Costa Rica, Dominican Republic]
	Mite	Tetranychidae [Dominican Republic, El Salvador]
	Mollusk	*Ovachlamys fulgens* (Helicarionidae), *Pallifera costaricensis* (Philomycidae), *Succinea costaricana*, *Succinea* sp. (Succineidae), Veronicellidae [Costa Rica]
Codiaeum variegatum	Insect	*Leucothrips* sp. (Thripidae), Cicadellidae, Coccidae, Noctuidae, and Pseudococcidae [Costa Rica], Thripidae [Dominican Republic]
	Mollusk	*Succinea costaricana* (Succineidae) [Costa Rica]
Colocasia esculenta	Insect	*Dyscinetus* sp. (Scarabaeidae), *Planococcus* sp. (Pseudococcidae), Cecidomyiidae and Curculionidae [Costa Rica]
Colocasia sp.	Insect	Cecidomyiidae, Curculionidae, and Pseudococcidae [Costa Rica]
Cordyline fruticosa	Insect	Cicadellidae, Noctuidae, Pentatomidae, Pseudococcidae, Pyraloidea, and Tettigoniidae [Costa Rica]

Commodity	Pest type	Pest name (family) [origin of shipment]
Cordyline sp.	Disease	*Mycosphaerella* sp. (Mycosphaerellaceae), *Phoma* sp., *Phomopsis* sp. (Coelomycetes) [Costa Rica]
	Insect	*Anchonus* sp. (Curculionidae), Cicadellidae, Noctuidae, Pentatomidae, Pseudococcidae, Tettigoniidae, and Tortricidae [Costa Rica]
	Mollusk	*Succinea costaricana* (Succineidae) [Costa Rica]
Cornus sp.	Mite	Tetranychidae [Costa Rica]
Cotoneaster sp.	Mite	Tetranychidae [Costa Rica]
Croton sp.	Insect	*Leucothrips* sp. (Thripidae) [El Salvador]
Ctenanthe sp.	Mollusk	*Ovachlamys fulgens* (Helicarionidae) [Costa Rica]
Cuphea sp.	Mite	Tetranychidae [Dominican Republic]
Cycad sp.	Insect	Coccoidea and Pentatomoidea [Costa Rica]
Cycas revoluta	Insect	Noctuidae, Tettigoniidae, and Tortricidae [Costa Rica]
Dendranthema sp.	Insect	*Liriomyza huidobrensis* (Agromyzidae) [Colombia]
Dendrobium sp.	Mollusk	*Succinea costaricana* (Succineidae) [Costa Rica]
Dianella sp.	Disease	*Mycosphaerella* sp. (Mycosphaerellaceae), *Pestalotiopsis* sp. (Coelomycetes) [Costa Rica]
	Mite	Tetranychidae [Costa Rica]
Dieffenbachia sp.	Insect	Pseudococcidae and Tetranychidae [Costa Rica]
Dizygothecea sp.	Insect	*Phyllophaga* sp. (Scarabaeidae) [Costa Rica]
Dracaena bicolor	Insect	Cicadellidae [Costa Rica]
Dracaena deremensis	Mollusk	*Succinea costaricana* (Succineidae) [Costa Rica]
Dracaena marginata	Insect	*Cyclocephala* sp. (Scarabaeidae), *Ozophora concava* (Rhyparochromidae), Cicadellidae, Coccidae, Coreidae, Diaspididae, Heteroptera, Noctuidae, Pentatomidae, Pseudococcidae, and Tettigoniidae [Costa Rica]
	Mollusk	*Succinea costaricana* (Succineidae), Veronicellidae [Costa Rica]
Dracaena massangeana	Disease	*Phoma* sp. (Coelomycetes) [Costa Rica]
	Insect	Curculionidae [Costa Rica]
Dracaena sp.	Disease	*Cercospora* sp. (Hyphomycetes), *Mycosphaerella* sp. (Mycosphaerellaceae), *Phomopsis* sp. (Coelomycetes) [Costa Rica]
	Insect	*Amblyrhetus* sp. (Gryllidae), Cicadellidae, Coccoidea, Coreidae, Diaspididae, Gryllidae, Heteroptera, Hymenoptera, Limacodidae, Noctuidae, Pentatomidae, Pseudococcidae, Syrphidae, Tettigoniidae, Tineidae, and Tortricinae [Costa Rica]
	Mollusk	*Deroceras* sp. (Agriolimacidae), *Ovachlamys fulgens* (Helicarionidae), *Succinea costaricana*, *Succinea* sp. (Succineidae) [Costa Rica]
Dracaena warneckii	Insect	Cicadellidae [Costa Rica]
Duranta sp.	Insect	*Bemisia tabaci* (Aleyrodidae) [Costa Rica]
	Mite	Tetranychidae [Costa Rica]
Epipremnum sp.	Insect	Pseudococcidae [Costa Rica, Dominican Republic]
	Mite	Tetranychidae [Costa Rica]
	Mollusk	Veronicellidae [Costa Rica]
Eryngium foetidum	Insect	Miridae [Costa Rica]
Euphorbia sp.	Insect	Aleyrodidae [Costa Rica] and Pseudococcidae [Dominican Republic]

Commodity	Pest type	Pest name (family) [origin of shipment]
Evolvulus sp.	Insect	*Frankliniella schultzei* (Thripidae) [Dominican Republic]
Gaillardia sp.	Insect	Aleyrodidae [Costa Rica]
Guzmania sp.	Disease	*Phoma* sp. (Coelomycetes) [Costa Rica]
Hedera sp.	Insect	Pseudococcidae [Costa Rica]
	Mite	Tetranychidae [Costa Rica]
Helianthemum sp.	Insect	Noctuidae [Colombia]
Heliconia psittacorum	Insect	Pseudococcidae [Costa Rica]
Heliconia sp.	Insect	Aphididae, Hesperiidae, and Pseudococcidae [Costa Rica]
Heliopsis sp.	Insect	Aleyrodidae [Costa Rica]
Hoya sp.	Insect	*Eurychilella* sp. (Miridae) [Costa Rica]
Lantana sp.	Insect	Aleyrodidae and Heteroptera [Costa Rica], *Leucothrips* sp. (Thripidae), Noctuidae, Tettigoniidae, and Thripidae [Dominican Republic]
	Mite	Tetranychidae [Dominican Republic]
Liriope sp.	Disease	*Mycosphaerella* sp. (Mycosphaerellaceae) [Costa Rica]
	Insect	Tettigoniidae [Costa Rica]
Luffa sp.	Insect	Noctuidae [Dominican Republic]
Mentha sp.	Insect	Noctuidae [Colombia]
Neoregelia sp.	Insect	Coccoidea [Costa Rica]
Ophiopogon sp.	Disease	*Mycosphaerella* sp. (Mycosphaerellaceae), *Phaeosphaeria* sp. (Phaeosphaeriaceae), *Phoma* sp. (Coelomycetes) [Costa Rica]
Orchidaceae	Insect	Lygaeoidea [El Salvador]
Pachysandra sp.	Insect	Pentatomoidea [Costa Rica]
	Mollusk	*Succinea costaricana* (Succineidae) [Costa Rica]
Philodendron sp.	Disease	*Pestalotiopsis* sp. (Coelomycetes) [Costa Rica]
	Insect	Diptera [Costa Rica]
Phormium sp.	Disease	*Colletotrichum rhodocyclum*, *Phoma* sp. (Coelomycetes) [Costa Rica]
Physostegia sp.	Mite	Tetranychidae [Costa Rica]
Pleomele sp.	Insect	Cicadellidae, Hymenoptera, Lepidoptera, Pentatomidae, and Tettigoniidae [Costa Rica]
Polyscias sp.	Disease	*Phyllosticta* sp. (Coelomycetes) [Costa Rica]
	Insect	Pseudococcidae [Costa Rica]
Rosa sp.	Insect	Tortricidae [Colombia]
Rosmarinus officinalis	Insect	Noctuidae [Colombia]
Ruella sp.	Mite	Tetranychidae [Dominican Republic]
Salvia sp.	Insect	Noctuidae [Dominican Republic]
	Mite	*Tetranychus* sp. [Costa Rica], Tetranychidae [Colombia, Dominican Republic]
Sansevieria sp.	Disease	*Colletotrichum* sp., *Fusicoccum* sp., *Phomopsis* sp. (Coelomycetes), *Didymosphaeria* sp. (Didymosphaeriaceae) [Costa Rica]
Scabiosa sp.	Disease	*Cladosporium* sp. (Hyphomycetes) [Colombia]
Schefflera arboricola	Insect	Aphididae, Cicadellidae, Coccidae, Coccoidea, Noctuidae, Pentatomidae, and Pseudococcidae, *Vinsonia stellifera* (Coccidae) [Costa Rica]
	Mite	Tetranychidae [Costa Rica]
	Mollusk	*Succinea costaricana* (Succineidae) [Costa Rica]

Commodity	**Pest type**	**Pest name (family) [origin of shipment]**
Schefflera sp.	Disease	*Phomopsis* sp. (Coelomycetes) [Costa Rica]
	Insect	*Cyclocephala* sp. (Scarabaeidae), *Protopulvinaria longivalvata*, *Vinsonia stellifera* (Coccidae), Agromyzidae, Aphididae, Cicadellidae, Coccidae, Coccoidea, Noctuidae, Pentatomidae, Plutellidae, Tettigoniidae, and Tortricidae [Costa Rica], Pseudococcidae [Costa Rica, El Salvador]
	Mite	Tetranychidae [Costa Rica]
	Mollusk	*Succinea costaricana* (Succineidae) [Costa Rica]
Solidago sp.	Insect	*Copitarsia* sp. (Noctuidae), Miridae [Colombia]
Tagetes sp.	Mite	Tetranychidae [Dominican Republic]
Theobroma cacao	Insect	Pseudococcidae [Costa Rica]
Thymus vulgaris	Insect	Aleyrodidae and Noctuidae [Colombia]
Tillandsia cyanea	Disease	*Diaporthe* sp. (Valsaceae), *Phomopsis* (Coelomycetes) [Belize]
Tillandsia sp.	Insect	Elachistidae [Costa Rica]
Tradescantia sp.	Mollusk	*Succinea* sp. (Succineidae) [Dominican Republic]
Verbena sp.	Insect	Aleyrodidae [Costa Rica]
Veronica sp.	Insect	Aleyrodidae [Costa Rica]
Vinca sp.	Insect	Aleyrodidae [Costa Rica]
Yucca elephantipes	Disease	*Phyllosticta yuccae* (Coelomycetes) [Costa Rica]
	Insect	*Bagnalliella* sp. (Phlaeothripidae) [Costa Rica]
Yucca sp.	Mollusk	*Veronicella* sp. (Veronicellidae) [Costa Rica]
Zamioculcas zamiifolia	Insect	Coccidae [Costa Rica]

Figure 9.1 Prevailing wind patterns in January (a) and July (b) (Lutgens and Tarbuck, 2007).

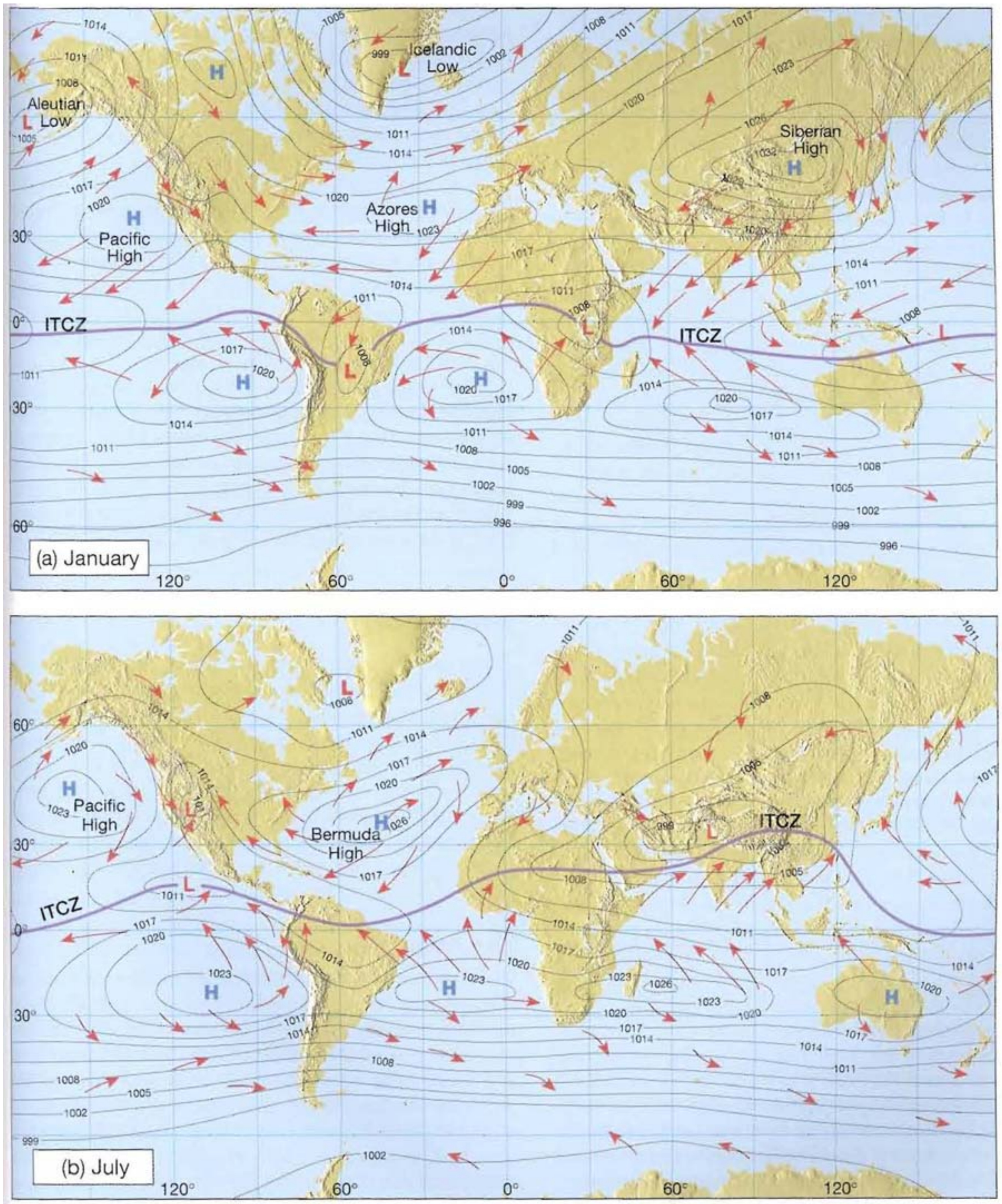


Figure 9.2 Areas and time of hurricane formation (Lutgens and Tarbuck, 2007).

Appendix

Pests potentially associated with forest products and with the potential to move into and within the Greater Caribbean Region. (Abbreviations: WPM-Wood Packaging Material; AF-Africa; AS-Asia; CAM-Central America; CAR-Caribbean; EUR-Europe; NAM-North America; OCE-Oceania; SAM-South America. Distribution country codes are in conformance with ISO 3166 codes; a list of countries and continents is located at the end of this table.)

Species	Order: Family	Distribution	Hosts	Pathways	Comments	References
INSECTS						
Apate monachus	Coleoptera: Bostrichidae	CAR (CUB, DMA, GLP, JAM, MTQ, PRI), BRA, AS, EUR, AF	Hardwoods, incl. *Acacia, Casuarina, Citrus, Coffea, Malus, Mangifera, Morus, Olea, Prunus, Psidium, Pyrus, Robinia, Swietenia, Theobroma, Vitis*	dead wood	Can attack living trees (*e.g.*, *Swietenia* spp., causing retarded growth, deformation and breaking); intercepted in USA (FL)	(CATIE, 1992, CABI-FC, 2008)
Bostrychopsis jesuita	Coleoptera: Bostrichidae	AUS	Hardwoods & conifers, incl. *Corymbia, Eucalyptus; Pinus pinaster*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Dinoderus minutus	Coleoptera: Bostrichidae	AS (native), EUR, AF, USA (CA, FL), CAR (CUB, TTO), SAM (BRA, CHL)	Polyphagous - hosts incl. *Bambusa, Dendrocalmus, Guadua angustifolia, Manihot esculenta, Ochlandra travancoria, Phyllostachys; Pinus*	bamboo, conveyances, poles/piles, sawn wood, WPM		(NZMAF, 2003, CABI-FC, 2008)
Heterobostrychus aequalis	Coleoptera: Bostrichidae	EUR, IND, AS, ZAF, IRN, IRQ	Hardwoods: freshly felled trees, green or seasoned timber, untreated timber (poles, piles)	bark, manufactured wood (furniture, souvenirs), poles/ piles, sawn wood, WPM		(NZMAF, 2003, AQIS, 2007)
Heterobostrychus brunneus	Coleoptera: Bostrichidae	AF (sub-Saharan), USA (CA)	Hardwoods	untreated timber (poles, piles), wood handicrafts, WPM		(Pasek, 2000, NZMAF, 2003, Haack, 2006, Schabel, 2006, USDA-APHIS, 2007)
Mesoxylion collaris	Coleoptera: Bostrichidae	AUS	*Corymbia, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Sinoxylon anale	Coleoptera: Bostrichidae	AUS, SAM (BRA, VEN), AS, SAU, NZL, USA (CA, FL, MI, NY, OH, PA)	Hardwoods, incl. *Acacia, Albizia, Casuarina, Dalbergia sissoo, Delonix regia, Eucalyptus*	logs, untreated timber (poles/piles), wood handicrafts, WPM	High risk potential for importation on *Eucalyptus* logs	(Pasek, 2000, Teixera *et al.*, 2002, NZMAF, 2003, USDA-FS, 2003, USDA-APHIS, 2007, CABI-FC, 2008)
Sinoxylon crassum	Coleoptera: Bostrichidae	AF (east), IND, PAK, AS (southeast)	*Acacia tortilis*	WPM		(Singh Rathore, 1995, Pasek, 2000, Walker, 2006)
Xylion cylindricus	Coleoptera: Bostrichidae	AUS	*Corymbia, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Xylodelis obsipa	Coleoptera: Bostrichidae	AUS	*Corymbia, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Xylopsocus gibbicollis	Coleoptera: Bostrichidae	AUS	*Corymbia, Eucalyptus*	Logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)

Species	Order: Family	Distribution	Hosts	Pathways	Comments	References
Xylothrips flavipes	Coleoptera: Bostrichidae	NCL, PNG, USA (HI), FJI, SLB		wood handicrafts, WPM		(Lesne, 1900, Pasek, 2000, Nardi, 2004, USDA-APHIS, 2007, PaDIL, 2008)
Xylothrips religiosus	Coleoptera: Bostrichidae	AUS	*Corymbia, Eucalyptus*	logs, poles/piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Xylotillus lindi	Coleoptera: Bostrichidae	AUS	*Corymbia, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Zelotypia stacyi	Coleoptera: Bostrichidae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Agrilus opulentus	Coleoptera: Buprestidae	PNG	*Eucalyptus*	bark, poles/piles, sawn wood		(NZMAF, 2003, CABI-FC, 2008)
Agrilus planipennis	Coleoptera: Buprestidae	AS (native), USA (MI, OH, IN, IL, MD, PA, WV, WI, MO, VA, IL), CAN	*Fraxinus*	firewood, nursery stock, logs, wood chips, WPM	Threat to Gulf States (in chips, can survive heat treatments 48 hrs at 40C)	(McCullough *et al.*, 2007, CABI-FC, 2008, ISSG, 2008)
Agrilus sexsignatus	Coleoptera: Buprestidae	PHL	*Eucalyptus*	bark, poles/piles, sawn wood		(NZMAF, 2003, CABI-FC, 2008)
Buprestis haemorrhoidalis	Coleoptera: Buprestidae	EUR, KAZ		WPM		(Pasek, 2000, Löbl and Smetana, 2006)
Melanophila cuspidata	Coleoptera: Buprestidae	AF (south), EUR (south)		WPM		(Pasek, 2000, Kubán, 2004)
Anoplophora chinensis	Coleoptera: Cerambycidae	AS (native), EUR (ITA), USA (WA)	Polyphagous - incl. *Citrus, Populus, Salix*	bonsai trees, nursery stock, wood and wood products		(CABI-FC, 2008, PaDIL, 2008)
Anoplophora glabripennis	Coleoptera: Cerambycidae	AS (CHN, KOR, JPN [native]), USA (northeast)	Hardwoods, incl. *Acer, Betula, Fraxinus, Hibiscus, Melia, Morus, Populus, Prunus, Pyrus, Robinia, Salix, Ulmus*	bark, poles/piles, sawdust, timber, wood chips, WPM	Very destructive; more recently has become a pest in China; ALB can attack healthy trees; beetle is able to survive and finish development in cut logs	(Magnusson *et al.*, 2001, NZMAF, 2003, AQIS, 2007, FAO, 2007b)
Apriona cinerea	Coleoptera: Cerambycidae	AS (IND [native])	*Populus*	bark, poles/piles, sawn wood	Bores into the wood of young poplars	(NZMAF, 2003, FAO, 2007c)
Arhopalus ferus	Coleoptera: Cerambycidae	EUR (native), NZL	Burned or windthrown conifers	cargo loaded during flight period (summer), timber		(AQIS, 2007)
Callidiellum rufipenne	Coleoptera: Cerambycidae	AS (native), USA (NC, CT, WA), ITA	Conifers, incl. *Chamaecyparis*, *Cryptomeria*, *Cupressus*, *Juniperus*, *Thuja*	artificial Christmas trees, plants, logs, wood handicrafts, WPM		(Hoebeke, 1999, Pasek, 2000, USDA-APHIS, 2007, CABI-FC, 2008, EPPO, 2008)
Callidiopsis scutellaris	Coleoptera: Cerambycidae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Chlorophorus annularis	Coleoptera: Cerambycidae	AS (native)	bamboo; hardwoods, incl. *Liquidambar formosa, Malus, Tectona grandis*	bamboo		(INBAR, 2008)
Chlorophorus strobilicola	Coleoptera: Cerambycidae	AS (IND) (native)	*Pinus roxburghii*; *P. kesiya*	pinecones	Found on scented pinecones by PPQ employees	(USDA-APHIS, 2004, CABI-FC, 2008)
Coptocercus rubripes	Coleoptera: Cerambycidae	AUS	*Angophora intermedia, Corymbia maculata, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Epithora dorsalis	Coleoptera: Cerambycidae	AUS	*Angophora intermedia, Corymbia maculata, Eucalyptus, Gmelina leichhardtii*	bark, logs, poles/ piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)

Species	Order: Family	Distribution	Hosts	Pathways	Comments	References
Hesperophanes campestris	Coleoptera: Cerambycidae	AS (CHN, JPN) (native)	Hardwoods & conifers: *Acer, Alnus, Betula, Camellia, Citrus, Fagus, Juglans, Malus, Morus, Populus, Quercus, Salix, Ulmus; Abies, Larix, Picea*	bark, sawn wood, untreated timber (poles/piles), wood chips, WPM		(NZMAF, 2003, CABI-FC, 2008)
Hesperophanes fasciculatus	Coleoptera: Cerambycidae	CHN	*Ceratonia siliqua, Cedrus atlantica*, multiple fruit trees and vines, also forest trees (e.g., *Betula*)	bark, poles/piles, sawn wood, wood chips, WPM	Frequently intercepted in USA, entry potential, likelihood of establishment, consequences of introduction all high risk	(USDA-APHIS, 1998, NZMAF, 2003, CABI-FC, 2008)
Hesthesis cingulata	Coleoptera: Cerambycidae	AUS	*Eucalyptus*	bark, poles/piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Hoplocerambyx spinicornis	Coleoptera: Cerambycidae	EUR, IND (native)	*Anisoptera glabra, Hopea odorata, Parashorea , Shorea robusta*	poles/piles, sawn wood	Causes severe damage - larvae girdle and kill trees and riddle heartwood with large tunnels or galleries	(NZMAF, 2003, FAO, 2007c, CABI-FC, 2008)
Hylotrupes bajulus	Coleoptera: Cerambycidae	EUR, TUR, AF, SAM, USA, CHN	Seasoned timber - conifers: *Abies, Picea, Pinus* (esp. roof timbers)	imports of seasoned timber or manufactured wood		(AQIS, 2007)
Macrones rufus	Coleoptera: Cerambycidae	AUS	*Eucalyptus*	bark, logs, poles/ piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Monochamus alternatus	Coleoptera: Cerambycidae	AS (native)	*Pinus, Abies firma, Abies fabri, Larix, Picea*	bark, poles/piles, sawn timber, wood handicrafts, wood chips, WPM	*Monochamus* species are the main vectors for pine wilt nematode (*B. xylophilus*) - can survive in wood chips	(Pasek, 2000, Magnusson *et al.*, 2001, NZMAF, 2003, Kawai *et al.*, 2006, USDA-APHIS, 2007, CABI-FC, 2008)
Phlyctaenodes pustulosus	Coleoptera: Cerambycidae	AUS	*Casuarina, Eucalyptus*	bark, logs, poles/ piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Phoracantha acanthocera	Coleoptera: Cerambycidae	AUS	*Angophora lanceolata, Agathis robusta, Araucaria cunninghamii, Corymbia, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Phoracantha mastersi	Coleoptera: Cerambycidae	AUS	*Corymbia maculata, Acacia , Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Phoracantha odewahni	Coleoptera: Cerambycidae	AUS	*Acacia , Corymbia calophylla, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Phoracantha punctipennis	Coleoptera: Cerambycidae	AUS	*Corymbia calophylla, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Phoracantha recurva	Coleoptera: Cerambycidae	AUS, PNG (native), NZL, EUR, AF, SAM, USA (CA)	*Angophora, Cupressus lusitanica, Eucalyptus, Syncaepia*	bark, logs, nursery stock, railway sleepers, sawn timber, logs, WPM	High risk potential for importation on *Eucalyptus* logs	(FAO, 2007a, CABI-FC, 2008)
Phoracantha semipunctata	Coleoptera: Cerambycidae	AUS (native), BRA, ZAF	*Angophora intermedia, Corymbia, Eucalyptus, Syncarpia laurifolia*	crates, *Eucalyptus* timber; freshly cut railway sleepers	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003, FAO, 2007a, Nair, 2007, CABI-FC, 2008)
Phoracantha solida	Coleoptera: Cerambycidae	AUS	*Angophora intermedia, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Phoracantha tricuspis	Coleoptera: Cerambycidae	AUS	*Eucalyptus*	bark, logs, poles/ piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Plagionotus christophi	Coleoptera: Cerambycidae	AS (CHN, JPN, KOR) [northeast])	Hardwoods, esp. *Quercus*	wood handicrafts, WPM		(Cherepanov, 1988, Pasek, 2000, KFS, 2004, USDA-APHIS, 2007)

Species	Order: Family	Distribution	Hosts	Pathways	Comments	References
Pyrrhidium sanguineum	Coleoptera: Cerambycidae	EUR, AF (north), AS (western)	Hardwoods, esp. *Quercus*	wood handicrafts, WPM	One of the most common longhorn beetles of central Europe	(Pasek, 2000, Hoskovec and Rejzek, 2006, USDA-APHIS, 2007)
Scolecobrotus westwoodi	Coleoptera: Cerambycidae	AUS	*Amyema , Corymbia gummifera, Eucalyptus*	bark, logs, poles/piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Stromatiium barbatum	Coleoptera: Cerambycidae	IND, LKA, BUR, MUS, MDG, PAK, NPL, TZA	350 species of seasoned hardwoods and conifers; attacks teak (*Tectona grandis*)	bamboo, manufactured wood (furniture, cricket bats), wood handicrafts, WPM	Serious pest of logged wood	(CAB, 1985, Pasek, 2000, AQIS, 2007, USDA-APHIS, 2007, CABI-FC, 2008, INBAR, 2008)
Stromatium longicorne	Coleoptera: Cerambycidae	CHN	*Canarium album, Ficus religiosa*	poles/piles, sawn wood		(NZMAF, 2003, CABI-FC, 2008)
Tessaromma undatum	Coleoptera: Cerambycidae	AUS	*Acacia dealbata, Eucalyptus, Nothofagus moorei*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Tetropium castaneum	Coleoptera: Cerambycidae	AS, EUR (native)	Hardwoods & conifers, incl. *Acer, Juglans, Quercus; Abies, Larix, Piceae, Pinus*		Intercepted in Canada and U.S.	(CABI-FC, 2008)
Tetropium fuscum	Coleoptera: Cerambycidae	Eurasia (native) CAN (NS)	*Abies, Larix, Picea,* and *Pinus*, occasionally hardwoods	bark, sawn wood, untreated timber (poles, piles), wood chips, WPM		(Magnusson *et al.*, 2001, NZMAF, 2003, Kimoto and Duthie-Holt, 2006, NRCAN, 2007)
Xylotrechus grayi	Coleoptera: Cerambycidae	CHN, JPN, KOR, THA		wood handicrafts, WPM		(Pasek, 2000, Hua, 2002, USDA-APHIS, 2007)
Xylotrechus magnicollis	Coleoptera: Cerambycidae	AS		wood handicrafts, WPM		(Pasek, 2000, Hua, 2002, USDA-APHIS, 2007)
Zygocera canosa	Coleoptera: Cerambycidae	AUS	*Eucalyptus*	bark, logs, poles/ piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Brontispa longissima	Coleoptera: Chrysomelidae	IND, PNG (native); AS	Over 20 species of palm, including *Cocos nucifera*	movement of infested palms	Potentially the most serious pest of coconut palms; where an attack is severe, complete defoliation of palms may result; prolonged attack may result in tree death	(FAO, 2007b, APFISN, 2008)
Chrysophtharta agricola	Coleoptera: Chrysomelidae	AUS	*Eucalyptus*	bark, logs, poles/ piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Chrysophtharta bimaculata	Coleoptera: Chrysomelidae	AUS (native)	*Eycalyptus, Gahnia grandia, Nothofagus cuninghamii*	bark, poles/piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003)
Paropsis spp., (incl, *P. atomaria, P. charybdis, P. delittlei*)	Coleoptera: Chrysomelidae	AUS	*Eucalyptus*	bark, sawn wood, unprocessed logs, WPM	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003, CABI-FC, 2008)
Gonipterus scutellatus	Coleoptera: Curculionidae	AUS, NZL (native), EUR (west), USA (CA), SAM (ARG, BRA, CHL, URY), AF	*Eucalyptus*	bark of wood logs, conveyances, foliage, stems	Major defoliator of *Eucalyptus* species, can cause tree mortality	(FAO, 2007a, CABI-FC, 2008)
Hylobius abietis	Coleoptera: Curculionidae	EUR, AS, NZL	*Betula pendula, Fagus sylvatica, Larix, Pinus, Picea, Quercus robur*	bark, poles/piles, sawn wood		(NZMAF, 2003, CABI-FC, 2008)

Species	Order: Family	Distribution	Hosts	Pathways	Comments	References
Hylobius pales	Coleoptera: Curculionidae	CAN, USA (FL, LA, NC, others)	*Juniperus virginiana, Pinus*	bark, poles/piles, sawn wood		(NZMAF, 2003, CABI-FC, 2008)
Pissodes nemorensis	Coleoptera: Curculionidae	USA (FL, IL, LA, MO, NY, OH, OK, VA) (native), EUR, AS, ZAF	*Cedrus*, *Picea*, *Pinus*	bark, Christmas trees, logs, nursery stock, poles/piles, sawn wood	Potential vector of *Fusarium circinatum*	(NZMAF, 2003, FAO, 2007a, CABI-FC, 2008)
Pissodes pini	Coleoptera: Curculionidae	RUS, EUR (west)	*Pinus*, including *P. mungo, P. strobus, P. sylvestris*	WPM		(Kulinich and Orlinskii, 1998, Pasek, 2000, Bugwood, 2008)
Amasa truncatus	Coleoptera: Curculionidae: Scolytinae	AUS	*Angophora intermedia, Corymbia, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Ambrosiodmus apicalis	Coleoptera: Curculionidae: Scolytinae	AUS (native), NZL	Polyphagous	logs, sawn timber, WPM		(Brockerhoff *et al.*, 2006)
Ambrosiodmus compressus	Coleoptera: Curculionidae: Scolytinae	AUS (native), NZL	Polyphagous, incl. *Eucalyptus*	logs, sawn timber, WPM	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003, Brockerhoff *et al.*, 2006)
Arixyleborus rugosipes	Coleoptera: Curculionidae: Scolytinae	PHL (native)	Polyphagous	logs, sawn timber, WPM		(Brockerhoff *et al.*, 2006)
Carphoborus minimus	Coleoptera: Curculionidae: Scolytinae	EUR (ITA, ESP, TUR)	*Pinus sylvestris*	WPM	Intercepted in Gulf States (LA, FL)	(Haack *et al.*, 2006)
Coccotrypes carpophagus	Coleoptera: Curculionidae: Scolytinae	AF (native), USA, EUR (ESP, GBR, PRT), CAR (BMU, CUB, GRD, JAM, PRI, VIR)	Polyphagous; breeds in seeds of palms, especially *Sabal palmetto*	logs, sawn timber, WPM	Intercepted in Gulf States (TX, FL)	(Bright, 1985, Atkinson and Peck, 1994, Haack, 2001, Brockerhoff *et al.*, 2006, PaDIL, 2008)
Coptodryas eucalyptica	Coleoptera: Curculionidae: Scolytinae	AUS (native), NZL	Polyphagous	logs, sawn timber, WPM		(Brockerhoff *et al.*, 2006)
Cryphalus asperatus	Coleoptera: Curculionidae: Scolytinae	EUR (DEU, ITA)	Conifers & hardwoods, incl. *Abies*, *Chamaecyparis lawsoniana*, *Juniperus communis*, *Larix, Picea*; *Populus*, *Salix fragilis*	WPM	Intercepted in Gulf States (AL)	(Bright and Skidmore, 1997, Haack, 2001)
Cryphalus piceae	Coleoptera: Curculionidae: Scolytinae	EUR (FRA, ITA)	Conifers, incl. *Abies, Piceae, Larix, Pinus, Pseudotsuga*	WPM	Intercepted in Gulf States (LA, FL, AL)	(Haack, 2001)
Cryphalus wapleri	Coleoptera: Curculionidae: Scolytinae	AUS (native), NZL	*Ficus*	logs, sawn timber, WPM		(Brockerhoff *et al.*, 2006)
Crypturgus cinereus	Coleoptera: Curculionidae: Scolytinae	EUR (AUT, BEL, DEU, ESP, RUS)	*Abies pectinata*, *Picea*, *Pinus halepensis*	WPM	Intercepted in Gulf States (LA, FL)	(Bright and Skidmore, 1997, Haack, 2001)
Crypturgus mediterraneus	Coleoptera: Curculionidae: Scolytinae	EUR (ESP, FRA, ITA, NND, PRT)	*Abies pinaspo*, *Pinus pinaster*	WPM	Intercepted in Gulf States (LA, FL, TX)	(Lombardero, 1995, Bright and Skidmore, 1997, Haack, 2001)
Crypturgus numidicus	Coleoptera: Curculionidae: Scolytinae	EUR (ESP, EST, GRC, LVA)	*Pinus halepensis*	WPM	Intercepted in Gulf States (TX)	(Diamantoglou and Banilas, 1996, Haack, 2001)

Species	Order: Family	Distribution	Hosts	Pathways	Comments	References
Dendroctonus frontalis	Coleoptera: Curculionidae: Scolytinae	USA (south), CAM (native)	*Pinus* (including *P. caribaea*)	bark, poles/piles, sawn wood	Most damaging insect to pine forests in Central America	(NZMAF, 2003, Nair, 2007, CABI-FC, 2008, FAO, 2008)
Dendroctonus terebrans	Coleoptera: Curculionidae: Scolytinae	USA (Gulf States, OK)	*Pinus*	bark, poles/piles, sawn wood		(NZMAF, 2003, CABI-FC, 2008)
Dryocoetes autographus	Coleoptera: Curculionidae: Scolytinae	AS, EUR, NAM, AF (north) (native), BRA	*Picea, Pinus*	bark, logs, sawn timber, wood chips, WPM	Frequently intercepted in New Zealand; intercepted in Gulf States (TX, FL, AL)	(Haack, 2001, NZMAF, 2003, Brockerhoff *et al.*, 2006)
Dryocoetes villosus	Coleoptera: Curculionidae: Scolytinae	EUR (BEL, DEU, FRA, GBR, ITA)	*Populus, Quercus*	bark, poles/piles, sawn wood, wood chips, WPM	Intercepted in Gulf States (AL, LA, TX, FL)	(Haack, 2001, NZMAF, 2003, Brockerhoff *et al.*, 2006)
Euwallacea fornicatus	Coleoptera: Curculionidae: Scolytinae	AS (native), AF, OCE, USA (HI), CAM (CRI, PAN), USA (CA, FL)	*Acer negundo, Alnus rubra, Camellia sinensis, Cedrela odorata, Gmelina arborea, Persea americana, Platanus racemosa, Robinia pseudoacacia, Tectona grandis*	logs, sawn timber, WPM	Colonized old growth forests in Central America - scolytine bark and ambrosia beetles seem to be the exception to the rule that interior, old growth, species-rich ecosystems are immune to exotic pests	(Kirkendall and Ødegaard, 2007, CABI-FC, 2008)
Euwallacea valida	Coleoptera: Curculionidae: Scolytinae	AS (native)	Polyphagous	logs, sawn timber, WPM	Intercepted in NZ on WPM from China and Japan	(Brockerhoff *et al.*, 2003, Brockerhoff *et al.*, 2006)
Euwallacea validus	Coleoptera: Curculionidae: Scolytinae	AS, CAM (CRI), USA (LA, MD, NY, PA)	Hardwoods & conifers, incl. *Acer, Carpinus, Castanea, Dalbergia, Fagus, Juglans, Phellodendron, Populus, Prunus, Quercus, Tilia, Ulmus; Abies, Chamaecyparis, Pinus, Tsuga*	furniture, wood handicrafts, WPM	Intercepted in USA	(Pasek, 2000, Haack, 2001, USDA-APHIS, 2007, Cognato, 2008)
Gnathotrichus materiarius	Coleoptera: Curculionidae: Scolytinae	CAR (DOM) USA (OR, SD), EUR (west)	*Pinus*	bark, poles/piles, sawn wood, wood chips, WPM		(Magnusson *et al.*, 2001, Mudge *et al.*, 2001, NZMAF, 2003)
Hylastes angustanus	Coleoptera: Curculionidae: Scolytinae	AS, EUR (native), AF	*Pinus, Picea*	logs, sawn timber, WPM	Intercepted in USA	(Haack, 2001, Brockerhoff *et al.*, 2006, FAO, 2007a)
Hylastes ater	Coleoptera: Curculionidae: Scolytinae	AS, EUR, AF (north) (native), NZL, AUS, CHN	*Abies alba, Chamaecyparis lawsoniana, Larix decidua, Pinus*	logs, sawn timber, wood handicrafts, WPM	Frequently intercepted in New Zealand; may vector root diseases (*e.g.*, *Ophiostoma* spp.); intercepted in Gulf States (TX, FL)	(Haack, 2001, Brockerhoff *et al.*, 2006, USDA-APHIS, 2007, CABI-FC, 2008)
Hylastes attenuatus	Coleoptera: Curculionidae: Scolytinae	EUR (ESP, FRA, ITA, PRT), ZAF	*Pinus pinaster*	WPM	Intercepted in Gulf States (FL, AL)	(Haack, 2001, Sousa *et al.*, 2002)
Hylastes cunicularius	Coleoptera: Curculionidae: Scolytinae	EUR (BEL, DEU, ESP, ITA)	*Picea abies*	WPM	Intercepted in Gulf States (AL, FL)	(Haack, 2001, Reay *et al.*, 2001)
Hylastes linearis	Coleoptera: Curculionidae: Scolytinae	AS, EUR, AF (north) (native), ZAF	*Pinus*	logs, sawn timber, WPM	Intercepted in Gulf States (FL, TX)	(Haack, 2001, Brockerhoff *et al.*, 2006)

Species	Order: Family	Distribution	Hosts	Pathways	Comments	References
Hylastes opacus	Coleoptera: Curculionidae: Scolytinae	BRA, CAN, USA (ME, NH, NY, OR, WV), RUS	*Larix decidua*, *Pinus*	WPM	Intercepted in Gulf States (TX)	(Bright and Skidmore, 1997, Haack, 2001, Mudge *et al.*, 2001, de Groot and Poland, 2003, Haack, 2006)
Hylastes toranio	Coleoptera: Curculionidae: Scolytinae	AS, EUR, AF (north) (native), ARG	*Fraxinus*	logs, sawn timber, WPM		(Brockerhoff *et al.*, 2006)
Hylesinus varius	Coleoptera: Curculionidae: Scolytinae	AS, EUR (BEL, GBR, ITA), AF (north) (native)	*Fraxinus*	logs, sawn timber, WPM	Frequently intercepted in New Zealand intercepted in Gulf States (FL)	(Haack, 2001, Brockerhoff *et al.*, 2006)
Hylurgops glabratus	Coleoptera: Curculionidae: Scolytinae	EUR (ITA)	*Picea abies*	WPM	Intercepted in Gulf States (LA, TX)	(Haack, 2001, Jacobs *et al.*, 2003)
Hylurgops palliatus	Coleoptera: Curculionidae: Scolytinae	EUR (BEL, DEU, ESP, GBR), USA (PA)	*Picea abies*	wood handicrafts, WPM	Intercepted in Gulf States (TX)	(Haack, 2001, Kohnle, 2004, Haack *et al.*, 2006, USDA-APHIS, 2007)
Hylurgus ligniperda	Coleoptera: Curculionidae: Scolytinae	EUR, AS, AF (native to MAR & TUN), ZAF, SAM (BRA, CHL, URY), AUS, NZL, USA (NY)	*Pinus*	logs, wood handicrafts, WPM	Beetle vectors several species of root disease fungi in the genus *Leptographium*; intercepted in Gulf States (FL, LA)	(Haack, 2001, Ahamed *et al.*, 2005, Haack, 2006, FAO, 2007a, USDA-APHIS, 2007)
Hypothenemus africanus	Coleoptera: Curculionidae: Scolytinae	CAM (CRI), CAR (JAM, VIR)	*Cecropria*	scrap wood and firewood	*Hypothenemus* species are found in dry and sunny areas; breed in dead twigs along forest edges; intercepted in USA	(Bright, 1985, Jordal and Kirkendall, 1998, Haack, 2001)
Hypothenemus birmanus	Coleoptera: Curculionidae: Scolytinae	Subtropics/tropics (native), USA (FL), CAR (CUB, JAM)	Polyphagous	logs, sawn timber, WPM	Intercepted in Gulf States (FL)	(Bright, 1985, Atkinson and Peck, 1994, Haack, 2001, Brockerhoff *et al.*, 2006)
Hypothenemus brunneus	Coleoptera: Curculionidae: Scolytinae	USA (FL)	Wide variety of hosts	?		(Atkinson and Peck, 1994)
Hypothenemus hampei	Coleoptera: Curculionidae: Scolytinae	CAM (native), CAR (JAM, CUB)	*Coffea*	logs, sawn timber, WPM	Not yet in Puerto Rico - devastating for coffee plantations; intercepted in Gulf States (FL, LA)	(Haack, 2001, Vega *et al.*, 2002, Brockerhoff *et al.*, 2006)
Ips acuminatus	Coleoptera: Curculionidae: Scolytinae	CHN, EUR (ESP, FRA, ITA, RUS)	*Pinus sylvestris*	bark, sawn wood, untreated timber (poles, piles), wood handicrafts, WPM	Intercepted in Gulf States (LA, FL, TX)	(Guérard *et al.*, 2000, Haack, 2001, NZMAF, 2003, USDA-APHIS, 2007)
Ips amitinus	Coleoptera: Curculionidae: Scolytinae	EUR (central)	*Picea abies*	wood handicrafts, WPM	Intercepted in Gulf States (TX)	(Haack, 2001, USDA-APHIS, 2007, Witrylak, 2008)
Ips apache	Coleoptera: Curculionidae: Scolytinae	CAM (BLZ)	*Pinus* (including *P. caribaea*)	unseasoned sawn wood, WPM with bark	Breeds primarily in slash, broken, fallen or dying trees	(FAO, 2008)
Ips cembrae	Coleoptera: Curculionidae: Scolytinae	CHN, EUR (BEL, DEU, ITA)	*Larix, Picea, Pinus*	wood handicrafts, WPM	Intercepted in Gulf States (FL, TX)	(Haack, 2001, USDA-APHIS, 2007)
Ips mannsfeldi	Coleoptera: Curculionidae: Scolytinae	EUR (ESP, TUR)	*Pinus*	wood handicrafts, WPM	Intercepted in Gulf States (TX)	(Haack, 2001, Brockerhoff *et al.*, 2003, USDA-APHIS, 2007)

Species	Order: Family	Distribution	Hosts	Pathways	Comments	References
Ips sexdentatus	Coleoptera: Curculionidae: Scolytinae	AS, EUR (native)	*Abies, Picea, Pinus* (incl. *P. radiata*)	bark, sawn wood, untreated timber (poles, piles), wood handicrafts, WPM	Intercepted in Gulf States (FL, TX)	(Haack, 2001, NZMAF, 2003, USDA-APHIS, 2007, CABI-FC, 2008)
Ips typographus	Coleoptera: Curculionidae: Scolytinae	EUR, CHN, JPN, KOR, RUS (east)	Damaged and healthy softwoods and timber (with bark)	bark, sawn wood, untreated timber (poles, piles), wood handicrafts, WPM	Intercepted in Gulf States (TX, FL, LA)	(Haack, 2001, NZMAF, 2003, Haack, 2006, AQIS, 2007)
Orthotomicus angulatus	Coleoptera: Curculionidae: Scolytinae	AS (native), FJI	*Pinus, Tsuga*	logs, sawn timber, WPM	Frequently intercepted in New Zealand	(Brockerhoff *et al.*, 2006)
Orthotomicus erosus	Coleoptera: Curculionidae: Scolytinae	AS, EUR, AF (north) (native), ZAF, USA (CA), FJI	*Abies, Cedrus, Pinus, Pseudotsuga*	bark, logs, sawn timber, wood handicrafts, WPM	Frequently intercepted in New Zealand and United States; can attack healthy trees in an outbreak	(NZMAF, 2003, Lee *et al.*, 2005, Brockerhoff *et al.*, 2006, Haack, 2006, CABI-FC, 2008)
Orthotomicus laricis	Coleoptera: Curculionidae: Scolytinae	AS, EUR, AF (north) (native), CHN	*Picea, Pinus*	logs, sawn timber, WPM	Frequently intercepted in New Zealand and United States	(Haack, 2001, Brockerhoff *et al.*, 2006)
Orthotomicus proximus	Coleoptera: Curculionidae: Scolytinae	AS, EUR (native), MDG	*Pinus*	logs, sawn timber, WPM	Frequently intercepted in New Zealand; intercepted in Gulf States (TX)	(Haack, 2001, Brockerhoff *et al.*, 2006)
Orthotomicus suturalis	Coleoptera: Curculionidae: Scolytinae	EUR (DEU, EST, FRA, GBR)	Conifers: *Picea abies, Pinus sylvestris,* and others	WPM	Intercepted in Gulf States (AL, LA)	(Haack, 2001, Bugwood, 2008)
Phloeosinus armatus	Coleoptera: Curculionidae: Scolytinae	AS (native), USA	Conifers	logs, sawn timber, WPM		(Brockerhoff *et al.*, 2006)
Phloeosinus cupressi	Coleoptera: Curculionidae: Scolytinae	NAM (native), NZL, AUS, PAN	*Cupressus*	logs, sawn timber, WPM		(Brockerhoff *et al.*, 2006)
Phloeosinus perlatus	Coleoptera: Curculionidae: Scolytinae	AS (native)	Conifers	logs, sawn timber, WPM	Frequently intercepted in New Zealand	(Brockerhoff *et al.*, 2006)
Phloeosinus rudis	Coleoptera: Curculionidae: Scolytinae	EUR (BEL), JPN	Conifers	WPM	Intercepted in Gulf States (TX, LA)	(Haack, 2001, Brockerhoff *et al.*, 2006)
Phloeotribus scarabaeoides	Coleoptera: Curculionidae: Scolytinae	AS, EUR (south)	*Olea europaea*	WPM	Intercepted in Gulf States (FL)	(CRFG, 1997, Pasek, 2000, Haack, 2001, Rodríguez *et al.*, 2003)
Pityogenes bidentatus	Coleoptera: Curculionidae: Scolytinae	AS, EUR (native), MDG, USA	*Pinus*	logs, sawn timber, WPM	Frequently intercepted in New Zealand; intercepted in Gulf States (FL, TX, AL)	(Haack, 2001, Brockerhoff *et al.*, 2006, Haack, 2006)
Pityogenes bistridentatus	Coleoptera: Curculionidae: Scolytinae	EUR (ESP, FRA, GBR, ITA, TUR)	*Larix, Picea, Pinus*	WPM	Intercepted in Gulf States (FL, TX)	(Haack, 2001, Bugwood, 2008)
Pityogenes calcaratus	Coleoptera: Curculionidae: Scolytinae	EUR (ESP, FRA, ITA)	*Pinus*	WPM	Intercepted in Gulf States (FL, TX)	(Mendel *et al.*, 1991, Haack, 2001)
Pityogenes chalcographus	Coleoptera: Curculionidae: Scolytinae	AS, EUR (native), JAM	Conifers	logs, sawn timber, wood handicrafts, WPM	Frequently intercepted in New Zealand and United States	(Haack, 2001, Brockerhoff *et al.*, 2006, USDA-APHIS, 2007)

Species	Order: Family	Distribution	Hosts	Pathways	Comments	References
Pityogenes quadridens	Coleoptera: Curculionidae: Scolytinae	EUR (ESP, FIN, LTU, PRT, TUR)	Conifers: *Pinus (P. sylvestris),* occas. *Abies, Larix, Picea*	WPM	Intercepted in Gulf States (FL, AL, LA)	(Haack, 2001, Bugwood, 2008)
Pityogenes trepanatus	Coleoptera: Curculionidae: Scolytinae	EUR (LTU)	Conifers	WPM	Intercepted in Gulf States (TX)	(Haack, 2001)
Pityokteines curvidens	Coleoptera: Curculionidae: Scolytinae	AS, EUR (native), ARG, ZAF	*Abies*	logs, sawn timber, WPM	Could be a problem for native fir species in Central America; intercepted in Gulf States (TX)	(Haack, 2001, Brockerhoff *et al.*, 2006)
Pityokteines spinidens	Coleoptera: Curculionidae: Scolytinae	EUR (AUT, DEU, FRA, ITA, RUS)	*Abies*	WPM	Intercepted in Gulf States (TX, AL)	(Haack, 2001, Bugwood, 2008)
Pityophthorus pityographus	Coleoptera: Curculionidae: Scolytinae	EUR (DEU, FRA, ITA, NLD)	Hardwoods & conifers, incl. *Frangula, Padus; Abies, Larix, Picea, Pinus*	WPM	Intercepted in Gulf States (LA, FL)	(Haack, 2001, Bugwood, 2008)
Polygraphus poligraphus	Coleoptera: Curculionidae: Scolytinae	EUR (BEL, DEU, GBR, ITA, RUS)	*Picea abies*, occas. *Abies, Larix, Pinus strobus, P. sylvestris*	wood handicrafts, WPM	Intercepted in Gulf States (LA, FL)	(Haack, 2001, USDA-APHIS, 2007, Bugwood, 2008)
Polygraphus subopacus	Coleoptera: Curculionidae: Scolytinae	AS, EUR (ITA)	*Picea abies*	WPM	Intercepted in Gulf States (TX)	(Haack, 2001, Mandelshtam, 2002)
Pteleobius vittatus	Coleoptera: Curculionidae: Scolytinae	EUR (ITA)	*Ulmus*	WPM	Intercepted in Gulf States (FL)	(Haack, 2001)
Scolytus intricatus	Coleoptera: Curculionidae: Scolytinae	AS, EUR, AF	Hardwoods, incl. *Aesculus, Betula, Carpinus, Castanea, Corylus, Fagus, Ostrya, Quercus, Salix, Tilia, Ulmus*	bark, sawn wood, untreated timber (poles, piles), wood chips, WPM	Associated with oak decline; could vector *Ceratocystis fagacearum* more effectively than the current vector if it were to enter North America; intercepted in Gulf States (LA)	(Haack, 2001, NZMAF, 2003, CABI-FC, 2008)
Scolytus kirschii	Coleoptera: Curculionidae: Scolytinae	EUR (south & central), AS (native), ZAF	*Ulmus*	timber	Infestations can kill elm trees; the beetles also vector *Ophiostoma ulmi* and *O. novoulmi*	(FAO, 2007a, PaDIL, 2008)
Scolytus ratzeburgi	Coleoptera: Curculionidae: Scolytinae	FIN, RUS, UKR	*Betula*, *Ulmus*	bark, sawn wood, wood chips, WPM	Intercepted in Gulf States (LA)	(Haack, 2001, NZMAF, 2003, Kimoto and Duthie-Holt, 2006)
Scolytus rugulosus	Coleoptera: Curculionidae: Scolytinae	AS, EUR, AF (north) (native), ARG, CAN, USA, MEX, CAM (BRA, PER, URY)	Hardwoods	bark, logs, sawn timber, wood chips, WPM		(NZMAF, 2003, Brockerhoff *et al.*, 2006, CABI-FC, 2008)
Scolytus scolytus	Coleoptera: Curculionidae: Scolytinae	AS, EUR (native)	*Ulmus*	bark, logs, sawn timber, WPM	Frequently intercepted in New Zealand; intercepted in Gulf States (LA)	(Haack, 2001, NZMAF, 2003, Brockerhoff *et al.*, 2006)
Taphrorychus bicolor	Coleoptera: Curculionidae: Scolytinae	EUR (BEL, DEU, FIN, FRA, NLD)		WPM	Intercepted in Gulf States (TX, AL)	(Haack, 2001)
Taphrorychus villifrons	Coleoptera: Curculionidae: Scolytinae	AS, EUR, AF (north) (native)	Hardwoods, incl. *Castanea, Fagus, Quercus*	logs, sawn timber, WPM	Frequently intercepted in New Zealand; intercepted in Gulf States (LA)	(Haack, 2001, Brockerhoff *et al.*, 2006)

Species	Order: Family	Distribution	Hosts	Pathways	Comments	References
Tomicus minor	Coleoptera: Curculionidae: Scolytinae	BRA, ITA, NZL, TUR	Conifers: *Pinus*	wood handicrafts, WPM	Intercepted in Gulf States (FL)	(Haack, 2001, USDA-APHIS, 2007)
Tomicus n.sp.	Coleoptera: Curculionidae: Scolytinae	CHN (native)	Conifer: *Pinus yunnanensis*	bark, sawn wood, wood handicrafts, untreated timber, WPM	This new species of pine shoot beetle has caused extensive mortality of Yunnan pines in China, affecting over 200,000 ha of pine plantations	(FAO, 2007b)
Tomicus piniperda	Coleoptera: Curculionidae: Scolytinae	EUR (BEL, ESP, FRA, GBR, ITA), USA (OH)	Conifers: *Pinus*	bark, sawn wood, untreated timber (poles, piles), wood handicrafts, WPM	Intercepted in Gulf States (FL, TX, LA)	(Haack, 2001, NZMAF, 2003, Haack, 2006, USDA-APHIS, 2007)
Trypodendron domesticum	Coleoptera: Curculionidae: Scolytinae	EUR (ITA, TUR)		wood chips, WPM	Intercepted in Gulf States (FL, AL)	(Haack, 2001, Magnusson *et al.*, 2001)
Trypodendron signatum	Coleoptera: Curculionidae: Scolytinae	EUR (BEL, DEU, FRA, NLD)		wood chips, WPM	Intercepted in Gulf States (FL)	(Haack, 2001, Magnusson *et al.*, 2001)
Xyleborinus alni	Coleoptera: Curculionidae: Scolytinae	EUR (AUS, CZE, DEU, POL, RUS), JPN, USA (OR, WA)		WPM		(Mudge *et al.*, 2001)
Xyleborus affinis	Coleoptera: Curculionidae: Scolytinae	EUR, MEX, USA (AK, FL, HI, KS), SAM (BRA), CUB, JAM CAR	*Ceiba pentendra, Dracena fragrans, Juglans nigra, Macadamia integrifolia, Pinus*	poles/piles, sawn wood		(Bright, 1985, NZMAF, 2003, CABI-FC, 2008)
Xyleborus californicus	Coleoptera: Curculionidae: Scolytinae	CAN, RUS, USA (AR, CA, DE, MD, OR, SC)		WPM		(Mudge *et al.*, 2001)
Xyleborus dispar	Coleoptera: Curculionidae: Scolytinae	EUR, AS (native), USA (many states, incl. NC, SC)	Polyphagous - many hardwood species, some pine		Could be a threat to the Gulf States - APHIS regulated pest list	(CABI-FC, 2008)
Xyleborus eurygraphus	Coleoptera: Curculionidae: Scolytinae	AF (north), EUR (south and western), TUR	*Pinus, Quercus, Ulmus*	WPM	Intercepted in Gulf States (FL, TX)	(Haack, 2001, Cognato, 2008)
Xyleborus exiguus	Coleoptera: Curculionidae: Scolytinae	CAM (CRI, PAN)	*Brosimum utile*	logs, sawn timber, WPM	Found in second growth forests in Central America	(Kirkendall and Ødegaard, 2007)
Xyleborus glabratus	Coleoptera: Curculionidae: Scolytinae	AS (IND, BGD, MMR, JPN, TWN) (native), USA (SC, GA)	*Persea borbonia, Sassafras albidum* and others in Lauraceae	logs, WPM, wood products		(Fraedrich *et al.*, 2008, Koch and Smith, 2008)
Xyleborus mutilatus	Coleoptera: Curculionidae: Scolytinae	AS (native), USA (TN)	Hardwoods, incl. *Acer, Camellia, Carpinus, Castanea, Cinnamomum camphora, Fagus, Swetenia macrophylla*	firewood/fuelwood, nursery stock, WPM		(ISSG, 2008)

Species	Order: Family	Distribution	Hosts	Pathways	Comments	References
Xyleborus perforans	Coleoptera: Curculionidae: Scolytinae	AS, EUR, AUS, AF (native), USA (HI), SAM (PER)	Polyphagous, incl. *Acacia, Albizia, Anacardium, Carica papaya, Cinnamomum verum, Citrus, Cocos nucifera, Eucalyptus, Ficus, Hevea brasiliensis, Mangifera indica, Persea americana, Shorea robusta, Theobroma cacao*	logs, sawn timber, untreated timber (poles, piles), WPM	Frequently intercepted in New Zealand; high risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, Brockerhoff *et al.*, 2006, CABI-FC, 2008)
Xyleborus pfeili	Coleoptera: Curculionidae: Scolytinae	AF, AS, EUR, NZL, USA (MD, OR)		WPM		(Mudge *et al.*, 2001)
Xyleborus saxesenii	Coleoptera: Curculionidae: Scolytinae	AS, EUR, AF (north) (native), USA, SAM, OCE	Polyphagous	logs, sawn timber, WPM	Invasive in introduced range	(Brockerhoff *et al.*, 2006, CABI, 2007)
Xyleborus similis	Coleoptera: Curculionidae: Scolytinae	AS, AUS, PNG (native), AF, USA (TX, HI)	Polyphagous	logs, sawn timber, wood handicrafts, WPM	Invasive in introduced range	(Wood, 1960, Brockerhoff *et al.*, 2006, Rabaglia *et al.*, 2006, CABI, 2007, USDA-APHIS, 2007)
Xylechinus pilosus	Coleoptera: Curculionidae: Scolytinae	EUR		WPM	Intercepted in Gulf States (FL)	(Haack, 2001, Alonso-Zarazaga, 2004)
Xylosandrus compactus	Coleoptera: Curculionidae: Scolytinae	AS (native), USA (Gulf States, HI), BRA, CAR (CUB, VIR)	Hardwoods & conifers, incl. *Acacia, Castanea, Cedrela odorata, Cinnamomum verbum, Swietenia; Pinus*	Infested seedlings, saplings or cut branches	Pest of coffee in Hawaii	(Bright, 1985, CABI-FC, 2008)
Xylosandrus crassiusculus	Coleoptera: Curculionidae: Scolytinae	AS, PNG (native), AF, USA (Gulf States, HI), WSM, CAM (CRI, PAN)	*Calliandra, Castilla elastica, Tectona grandis, Topobea maurofernandeziana*	bamboo, bark, logs,sawn timber, untreated timber (poles, piles), wood chips, WPM	Invasive in North America (southern states); has been found in old growth, species-rich interior forests in Central America	(NZMAF, 2003, Brockerhoff *et al.*, 2006, Kirkendall and Ødegaard, 2007, CABI, 2008)
Xylosandrus germanus	Coleoptera: Curculionidae: Scolytinae	AS (native), USA (SE USA & HI), CRI, AF, IND	Polyphagous, incl. *Juglans, Malus*	logs, sawn timber, WPM		(Brockerhoff *et al.*, 2006, CABI-FC, 2008, PaDIL, 2008)
Xylosandrus morigerus	Coleoptera: Curculionidae: Scolytinae	AS (native), EUR, AF, MEX, SAM, CAM, OCE (some), CAR (PRI)	Polyphagous	logs, sawn timber, WPM	Invasive in Mexico, South America, Central America, AUS, other parts of Oceania; intercepted in Gulf States (FL, LA)	(Bright, 1985, Haack, 2001, Brockerhoff *et al.*, 2006, CABI, 2007)
Xylosandrus pseudosolidus	Coleoptera: Curculionidae: Scolytinae	AUS (native), NZL	Polyphagous	logs, sawn timber, WPM		(Brockerhoff *et al.*, 2006)
Xylosandrus solidus	Coleoptera: Curculionidae: Scolytinae	AUS (native), NZL	*Diploglottis, Eucalyptus*	logs, sawn timber, WPM	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003, Brockerhoff *et al.*, 2006)
Xyloterinus politus	Coleoptera: Curculionidae: Scolytinae	CAN, USA (WA)		WPM		(Mudge *et al.*, 2001)
Lyctus spp., incl. *L. brunneus, L. costatus, L. discenen, L. parallelocollis*	Coleoptera: Lyctidae	AUS	*Corymbia, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)

Species	Order: Family	Distribution	Hosts	Pathways	Comments	References
Minthea rugicollis	Coleoptera: Lyctidae	AUS	*Corymbia, Eucalyptus*	poles/piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Atractocerus crassicornis	Coleoptera: Lymexylidae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Atractocerus kreuslerae	Coleoptera: Lymexylidae	AUS	*Corymbia calophylla, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Austroplatypus incompertus	Coleoptera: Platypodidae	AUS	*Corymbia gummifera, Eucalyptus*	bark, logs, poles/ piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Crossotarsus externedentatus	Coleoptera: Platypodidae	KIR	*Eucalyptus, Swietenia macrophylla*	poles/piles, sawn wood		(NZMAF, 2003, CABI-FC, 2008)
Platypus australis	Coleoptera: Platypodidae	AUS	*Eucalyptus saligna*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Platypus subgranosus	Coleoptera: Platypodidae	AUS	*Eucalyptus nitens, Nothofagus cunninghamii*	bark, logs, poles/ piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003, CABI-FC, 2008)
Platypus tuberculosus	Coleoptera: Platypodidae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Asphondylia tectonae	Diptera: Cecidomyiidae	IND (native)	*Tectona grandis*		One of the few insects recorded as pests in naturally regenerated teak forests	(FAO, 2007c)
Pineus pini	Hemiptera: Adelgidae	EUR (native), AF, CHN, IND, USA (HI)	*Pinus caribaea*, *P. elliotti*, *P. taeda*, *P. patula*	bark, foliage, planting stock, seedlings, stems	Feeds on the shoots of *Pinus* spp. - causes tip dieback	(Culliney *et al.*, 1988, FAO, 2007c, Nair, 2007, CABI-FC, 2008)
Cinara cupressivora	Hemiptera: Aphididae	EUR (native), AF, AS, USA (AZ, CA, CO, PA, UT), SAM (CHL), MUS	Conifers: *Chamaecyparis, Cupressocyparis, Cupressus, Juniperus, Thuja*	nursery stock	Nominated as "among 100 of the world's worst invaders"	(FAO, 2007e, IUFRO, 2007, ISSG, 2008)
Chionaspis pinifoliae	Hemiptera: Diaspididae	NAM (native), AF, CAM (SLV, HND), CAR (CUB), SAM (CHL)	Conifers, incl. *Abies, Cedrus, Pinus*	Christmas trees and greenery		(CABI 2007, Bishop 1994)
Hemiberlesia pitysophila	Hemiptera: Diaspididae	AS (JPN, THA) (native)	*Pinus*, including *P. caribaea, P. elliotti, P. taeda, P. thunbergii*	bark, conveyances, infested plants, logs	This is an important alien invasive species in China - heavy infestations can kill pine trees within 3-5 years	(CABI, 2007, ISSG, 2008)
Eriococcus coriaceus	Hemiptera: Eriococcidae	AUS, NZL	*Acacia*, *Eucalyptus*	bark		(Ben-Dov and Hodgson, 1997, NZMAF, 2003, CABI-FC, 2008)
Paratachardina pseudolobata	Hemiptera: Kerriidae	AS (IND, LKA) (native), USA (FL), CAR	> 150 hosts, many native to Caribbean; *Acer, Bambusa, Quercus, etc.*; attacks tropical fruit trees, forest trees, landscape trees and shrubs	plants, twigs, and small branches	Considered to have an especially high potential for further spread, into the Caribbean Islands, Hawaii, etc. - "invasion of natural areas is of paramount concern"	(Pemberton, 2003, Ben-Dov *et al.*, 2006, Howard *et al.*, 2008, ISSG, 2008)
Matsucoccus matsumurae	Hemiptera: Margarodidae	CHN, JPN	*Pinus*			(CABI-FC, 2008)
Maconellicoccus hirsutus	Hemiptera: Pseudococcidae	JAM (invasive)	Fruit trees, forest trees (*e.g., Hibiscus elatus, Tectona grandis*)	infested fruit; propagative material		(Pollard, 1997, Kairo *et al.*, 2003)

Species	Order: Family	Distribution	Hosts	Pathways	Comments	References
Ctenarytaina eucalypti	Hemiptera: Psyllidae	AUS (native), BRA	*Eucalyptus*	bark		(NZMAF, 2003, Nair, 2007)
Glycaspis brimblecombei	Hemiptera: Psyllidae	MEX, USA (CA, FL, HI), CHL, AUS (native)	*Eucalyptus*	nursery plants	Could also move on bark	(NZMAF, 2003, CABI-FC, 2008)
Quadraspidiotus perniciosus	Hemiptera: Sternorrhyncha: Coccidae	CHN (native), (IND), EUR (central and eastern), AF, CAN, USA (CA, HI, NE states, TN), CAR (CUB), SAM, AUS, NZL	Hardwoods, incl. *Aesculus, Alnus, Betula, Celtis, Fagus, Fraxinus, Populus*	attacks wood, can also be found on leaves and fruits	Quarantine pest in different parts of the world - impacts trade, when new in a country can attack and kill whole trees and plantations	(FAO, 2007c, CABI-FC, 2008)
Leptocybe invasa	Hymenoptera: Eulophidae	AUS (native), IND, KEN, MAR, TZA, UGA), NZL	*Eucalyptus*	foliage, nursery stock	Newly described species currently spreading around the Mediterranean Basin and Africa	(FAO, 2007c, EPPO, 2008)
Camponotus pennsylvanicus	Hymenoptera: Formicidae	USA, CAN	Hardwoods & conifers, incl. *Carya, Populus tremuloides, Ulmus; Abies balsamea, Juniperus, Pinus strobus, P. rigida, Pseudotsuga menziesii, Thuja plicata*	bark, containers, sawn wood, untreated timber, WPM		(AQIS, 2007)
Sirex noctilio	Hymenoptera: Siricidae	NZL, AUS, SAM, ZAF, USA (NY, MI, PA)	Conifers, incl. *Abies, Larix, Picea, Pinus*	poles/piles, sawn wood, unprocessed logs, WPM	Vectors fungus *Amylostereum areolatum*, which kills trees	(NZMAF, 2003, Hoebeke *et al.*, 2005, Dodds *et al.*, 2007, FAO, 2007a, CABI-FC, 2008)
Tremex fuscicornis	Hymenoptera: Siricidae	EUR, AS (native), CHN, AUS	Hardwoods	wood and wood products, WPM		(CABI-FC, 2008)
Urocerus gigas	Hymenoptera: Siricidae	AS, EUR, USA, CAN, RUS	Conifers: *Abies, Larix, Picea, Pinus*) - recently cut, fallen or weakened trees, green timber	pine logs, sawn timber, untreated timber (poles/piles), WPM		(NZMAF, 2003, AQIS, 2007)
Xiphydria prolongata	Hymenoptera: Xiphydriidae	EUR (west), RUS, USA (MI, NJ, OR)		WPM		(Mudge *et al.*, 2001)
Bifiditermes condonensis	Isoptera: Kalotermitidae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Ceratokalotermes spoliator	Isoptera: Kalotermitidae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Cryptotermes brevis	Isoptera: Kalotermitidae	USA (FL, HI), CAM, CAR, AUS	Seasoned hardwoods & conifers, including *P. caribaea* and species within Aceraceae, Fagacae, Oleaceae, Tiliaceae, Ulmaceae, Cupressaceae, and Pinaceae	bamboo, bark, sawn wood, untreated timber (poles, piles), wood chips	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003, CABI-FC, 2008)
Cryptotermes cynocephalus	Isoptera: Kalotermitidae	AUS, USA (HI), AS (south & southeast)	Seasoned hardwoods and softwoods	logs, poles/piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(Scheffrahn *et al.*, 2000, NZMAF, 2003, USDA-FS, 2003)
Cryptotermes domesticus	Isoptera: Kalotermitidae	AUS	Seasoned hardwoods and softwoods	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)

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Cryptotermes dudleyi	Isoptera: Kalotermitidae	AUS, CAM (NIC)	Seasoned hardwoods and softwoods	logs	High risk potential for importation on *Eucalyptus* logs ; introduced into Nicaragua - pest species on dead wood	(USDA-FS, 2003, Scheffrahn *et al.*, 2005)
Glyptotermes tuberculatus	Isoptera: Kalotermitidae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Incisitermes minor	Isoptera: Kalotermitidae	USA, MEX, CAN	Drywood	bamboo, bark, poles/ piles, sawn wood, shipping containers, timber, yachts, wood chips		(NZMAF, 2003, AQIS, 2007)
Kalotermes banksiae	Isoptera: Kalotermitidae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Kalotermes rufinotum	Isoptera: Kalotermitidae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Neotermes insularis	Isoptera: Kalotermitidae	AUS	*Eucalyptus*	logs, poles/piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Mastotermes darwiniensis	Isoptera: Mastotermitidae	AUS	*Eucalyptus*, *Pinus caribaea*	sawn wood, poles/piles, logs	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Coptotermes acinaciformis	Isoptera: Rhinotermitidae	AUS	*Eucalyptus pilularis, Pinus radiata*	logs, poles/piles, sawn wood	Attacks living trees; high risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003, CABI-FC, 2008)
Coptotermes crassus	Isoptera: Rhinotermitidae	MEX, CAM (NIC)	Hardwoods & conifers, incl. *Cedrela odorata, Ceiba pentandra, Eucalyptus, Gmelina arborea, Mangifera indica, Quercus, Swietenia macrophylla; Pinus maximino, P. oocarpa*	logs, WPM	Pest species in Nicaragua; high risk potential for importation on *Pinus* logs	(Constantino, 1998, USDA-FS, 1998, Pasek, 2000, Scheffrahn *et al.*, 2005)
Coptotermes curvignathus	Isoptera: Rhinotermitidae	AS (IND, MYS, THA, VNM) (native)	Hardwoods & conifers, incl. *Cocos nucifera, Ficus elastica, Gmelina arborea, Mangifera indica; Pinus caribaea*	bamboo, bark, logs, poles/piles, sawn wood, wood chips, WPM	Pest of quarantine concern in China, New Zealand & Australia; can attack living trees	(NZMAF, 2003, CABI-FC, 2008)
Coptotermes formosanus	Isoptera: Rhinotermitidae	AS, ZAF, USA (including HI)	50+ spp. of hardwoods & conifers, incl. *Citrus, Quercus; Cupressus*	bamboo, bark, containers, sawn wood, untreated timber (poles, piles)	Attacks living trees	(Lai *et al.*, 1983, NZMAF, 2003, AQIS, 2007)
Coptotermes frenchi	Isoptera: Rhinotermitidae	AUS	*Eucalyptus*	logs, poles/piles, sawn wood	Attacks living trees; high risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003, CABI-FC, 2008)
Coptotermes lacteus	Isoptera: Rhinotermitidae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Coptotermes sjostedti	Isoptera: Rhinotermitidae	AF (native), CAR (GLP)	Hardwoods, incl. *Autranella congolensis, Entandrophragma cylindricum, E. utile, Triplochiton scleroxylon*	logs, poles/piles, sawn wood	Attacks living trees	(NZMAF, 2003, CABI-FC, 2008)
Heterotermes ferox	Isoptera: Rhinotermitidae	AUS	*Eucalyptus*, any hardwood or softwood	logs, poles/piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)

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Heterotermes paradoxus	Isoptera: Rhinotermitidae	AUS	*Eucalyptus*	logs, poles/piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Schedorhinotermes intermedius	Isoptera: Rhinotermitidae	AUS	*Eucalyptus*, any hardwood or softwood	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Schedorhinotermes reticulatus	Isoptera: Rhinotermitidae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Microcerotermes spp. (incl. *M. boreus, M. distinctus, M. implicatus, M. nervosus, M. turneri*)	Isoptera: Termitidae	AUS	*Eucalyptus*	poles/piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Nasutitermes costalis	Isoptera: Termitidae	CAR, GUY (native), USA (FL)	*Gmelina arborea*	shipping containers	On saplings; first termitid recorded established outside of its endemic range	(Scheffrahn *et al.*, 2002, Nair, 2007)
Nasutitermes exitiosis	Isoptera: Termitidae	AUS	*Eucalyptus*	logs, poles/piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Porotermes adamsonii	Isoptera: Termopsidae	AUS	Hardwoods & conifers, incl. *Araucaria cunninghamii, Ceratopetalum apetalum, Eucalyptus, Nothofagus cunninghamii; Pinus radiata*	bark, logs, poles/ piles, sawn wood	Listed as having a high risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Chilecomadia valdiviana	Lepidoptera: Cossidae	CHL	*Eucalyptus, Nothofagus allisandri*	logs		(Tkacz, 2001, CABI-FC, 2008)
Coryphodema tristis	Lepidoptera: Cossidae	ZAF (native)	Hardwoods, incl. *Eucalyptus* and species within Combretaceae, Malvaceae, Myoporaceae, Myrtaceae, Rosaceae, Scorphulariaceae, Ulmaceae, Vitaceae	fruits, roots, timber, viticulture	Wood-boring insect with a wide range of hosts (forest trees, ornamentals, vines), particularly damaging in *Eucalyptus* plantations	(FAO, 2007a, PaDIL, 2008)
Endoxyla cinereus	Lepidoptera: Cossidae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Endoxyla spp.	Lepidoptera: Cossidae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Xyleutes ceramicus	Lepidoptera: Cossidae	AS	*Callicarpa, Clerodendrum, Duabanga, Gmelina, Erythrina, Tectona grandis, Sesbania, Spathodea, Vitex parviflora*	bark, poles/piles, sawn wood	Considered "teak's worst and least understood pest" - bores into the heartwood of teak where it causes significant damage	(NZMAF, 2003, FAO, 2007d, Nair, 2007, CABI-FC, 2008)
Zeuzera coffeae	Lepidoptera: Cossidae	AS (THA) (native)	Hardwoods, incl. *Acalypha, Casuarina, Citrus, Coffea, Crataegus, Eucalyptus, Psidium, Terminalia, Theobroma,*		Larvae tunnel into the heartwood of living trees - degrade value of timber	(FAO, 2007d)
Abantiades latipennis	Lepidoptera: Hepialidae	AUS	*Eucalyptus*	bark, logs, poles/ piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Aenetus eximius	Lepidoptera: Hepialidae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)

Species	Order: Family	Distribution	Hosts	Pathways	Comments	References
Aenetus ligniveren	Lepidoptera: Hepialidae	AUS	Hardwoods, incl. *Acacia, Eucalyptus, Leptospermum, Malus pumila, Melaleuca, Rubus idaeus, Ulmus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Aenetus paradiseus	Lepidoptera: Hepialidae	AUS	*Eucalyptus*	bark, logs, poles/ piles, sawn wood	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003)
Dendrolimus pini	Lepidoptera: Lasiocampidae	AS, EUR, AF (MAR)	*Cedrus deodora, Picea, Pinus*	females lay eggs on bark, logs		(Bugwood, 2008, CABI-FC, 2008)
Dendrolimus punctatus	Lepidoptera: Lasiocampidae	CHN (native)	Conifers: *Pinus (*incl. *P. massoniana, P. radiata, P. taeda)*	material infested with egg masses	Major pest in pine plantations in central and southern China	(FAO, 2007b)
Dendrolimus sibiricus	Lepidoptera: Lasiocampidae	CHN (native)	Conifers, incl. *Abies, Larix, Pinus, Picea, Tsuga*	forest products, nursery stock	Is able to attack and kill healthy trees across wide areas	(FAO, 2007b)
Dendrolimus tabulaeformis	Lepidoptera: Lasiocampidae	CHN (native)	*Pinus*	forest products, nursery stock	Causes significant defoliation of both natural and planted forests	(FAO, 2007b)
Lymantria dispar	Lepidoptera: Lymantriidae	CHN (native), RUS (east), KOR, JPN, USA	Foliage of 600 plant species, (hardwood & conifer) incl. *Betula, Eucalyptus, Populus, Salix, Quercus, Ulmus; Larix, Pinus;*urban ornamental plants	containers, conveyances, egg masses on forest products, nursery stock	Destructive defoliator of a wide range of broadleaf trees; serious forest pest in China	(AQIS, 2007, FAO, 2007b)
Lymantria mathura	Lepidoptera: Lymantriidae	IND (native), AS, RUS	Hardwoods, incl. *Mangifera indica, Quercus, Shorea robusta,* additional hosts within Fagaceae, Salicaceae, Rosaceae, Betulaceae, Juglandacear, and Oleaceae	bark, foliage, nursery stock, untreated wood, treated wood, WPM	Serious defoliator in its native range; intercepted in USA	(CABI-FC, 2008)
Lymantria monacha	Lepidoptera: Lymantriidae	EUR, RUS (east)	Hardwoods & conifers, incl. *Acer, Ficus, Quercus, Ulmus; Larix*	cargo, forest products, shipping containers, ships		(AQIS, 2007)
Lymantria obfuscata	Lepidoptera: Lymantriidae	AS (IND, PAK) (native)	Hardwoods, incl. *Alnus, Cydomia, Juglans, Morus, Populus, Prunus, Pyrus, Quercus, Robinia, Rosa, Salix, Theobroma*	bark, logs with bark	Major pest of forest and fruit trees in India; trees may be killed if they are defoliated for more than one year; intercepted in Europe	(FAO, 2007c, CABI-FC, 2008)
Orgyia thyellina	Lepidoptera: Lymantriidae	CHN, KOR, JPN, RUS (east), THA	Many - urban/forest	cargo, forest products, shipping containers, ships		(AQIS, 2007)
Uraba lugens	Lepidoptera: Noctuidae	AUS	*Eucalyptus delegatensis*	bark, poles/piles, sawn wood		(NZMAF, 2003, CABI-FC, 2008)
Conogethes punctiferalis	Lepidoptera: Pyralidae	AS (CHN) (native)	Hardwoods & conifers, incl. *Castanea, Durio, Macadamia, Prunus; Pinus*	infested plants, seeds, or fruit	Causes significant damage to stems, fruits and seeds of host plants; in China, contributed to the loss of 25% of chestnut crops	(FAO, 2007b)
Dioryctria horneana	Lepidoptera: Pyralidae	CAR (CUB)	*Pinus caribaea*		Shoot moths are a problem in Latin America	(Nair, 2007)
Hypsipyla grandella	Lepidoptera: Pyralidae	USA (FL), CAM, CAR, MUS	*Carapa, Cedrela, Juniperus, Swietenia, Tabebuia*	?	Main pest of *Swietenia* and *Cedrela* in the New World	(CATIE, 1992, FAO, 2007e)

Species	Order: Family	Distribution	Hosts	Pathways	Comments	References
Hypsipyla robusta	Lepidoptera: Pyralidae	AS (south & southeast), AUS, AF (west & east), MUS	*Cedrella, Khaya, Swietenia, Tectona grandis, Toona ciliata*	?	Saplings are most susceptible to attack; mahogany shoot borers are the main hindrance to the expansion of mahogany throughout the tropics	(FAO, 2007e, Nair, 2007)
Didymuria violescens	Phasmatodea: Phasmatidae	AUS	*Eucalyptus*	bark, poles/piles, sawn wood	Periodic outbreaks occur in Australia, resulting in defoliation of entire patches or hillsides	(NZMAF, 2003, FAO-RAP, 2005, CABI-FC, 2008)
MITES						
Raoiella indica	Acari: Tenuipalpidae	IND (native), CAR	Palms, orchids, ornamentals, bananas	natural spread, palm handicrafts, people	Introduced into the Caribbean islands - threat to Greater Caribbean Region	(ISSG, 2008)
FUNGI						
Calonectria ilicicola	Ascomycetes: Nectriaceae	EUR	*Eucalyptus grandis, Gaultheria shallon, Laurus nobilis*	bark, poles/piles, sawn wood, wood chips		(NZMAF, 2003, CABI-FC, 2008)
Gymnopilus junonius	Agaricales: Cortinariaceae	AUS	*Corymbia, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Fistulina spiculifera	Agaricales: Fistulinaceae	AUS	*Corymbia calophylla, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Omphalotus nidiformis	Agaricales: Marasmiaceae	AUS	*Corymbia maculata, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Balansia linearis	Ascomycota: Clavicipitaceae	AS (IND) (native)	*Ochlandra*	reed bamboo	Poses a threat to the reed bamboo industry	(FAO, 2007c)
Chrysoporthe austroafricana	Ascomycota: Cryphonectriaceae	ZAF	*Eucalyptus, Syzygium, Tibouchina*	bark, roots, stems, wood	Causes one of the most important diseases of *Eucalyptus* planted in tropical and subtropical regions worldwide	(FAO, 2007a, CABI-FC, 2008)
Subramanianospora vesiculosa	Ascomycota: Incertae sedis	IND (native), IDN, MUS, THA, VNM	*Casuarina equisetifolia*	timber, WPM	Infected trees are ultimately killed; most destructive disease of *C. equisitifolia* in India	(FAO, 2007c, e)
Armillaria fuscipes	Basidiomycota: Marasmiaceae	ZAF (native)	Hardwoods & conifers: *Eucalyptus* & *Pinus*	bark, roots, stems, wood	A problem in *Pinus* and *Eucalyptus* plantations in native range	(FAO, 2007a, CABI-FC, 2008)
Trichosporum vesiculosum	Capnodiales:	AS (IND, LKA, MUS, IDN, VNM, THA), AF (KEN)	Casuarinaceae	bark, nursery stock, WPM		(AQIS, 2007)
Cryphonectria eucalypti	Diaporthales: Valsaceae	AUS	*Corymbia, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Mycosphaerella juvensis	Dothideales: Myco-sphaerellaceae	AF (KEN, ZAF, TZA, GMB)	*Eucalyptus*	bark, nursery stock, seeds		(AQIS, 2007)
Botryosphaeria ribis	Dothidiales: Botryospheriaceae	AUS, USA (FL, other Gulf States), CAR (CUB, TTO, BRB)	Hardwoods & conifers (100+ genera), incl. *Cersis, Citrus, Cornus, Corymbia, Eucalyptus, Liquidambar, Malus, Platanus, Prunus, Tilia, Ulmus; Pinus*	logs	Causal agent for botryosphaeria rot (bot rot or white rot); high risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003, Farr *et al.*, 2006)
Phacidium coniferarum	Helotiales: Phacidiaceae	EUR, CAN, USA (MA, OR, WA), CAM (HON, NIC),	*Cedrus deodora*	bark, poles/piles, sawn wood, wood chips		(NZMAF, 2003, CABI-FC, 2008)

Species	Order: Family	Distribution	Hosts	Pathways	Comments	References
		NZL				
Inonotus albertinii	Hymenochaetales: Hymeno-chaetaceae	AUS	*Eucalyptus obliqua*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Inonotus chondromyeluis	Hymenochaetales: Hymeno-chaetaceae	AUS	*Eucalyptus saligna*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Inonotus rheades	Hymenochaetales: Hymeno-chaetaceae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Phellinus gilvus	Hymenochaetales: Hymeno-chaetaceae	AUS	*Corymbia calophylla, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Phellinus noxius	Hymenochaetales: Hymeno-chaetaceae	AS, AF, OCE, CAM (CRI), CAR (CUB, PRI), AUS	Hardwoods, incl. *Camellia, Coffea, Cordia alliodora, Corymbia, Liquidambar formosana, Tectona grandis, Theobroma cacao,* and others	bark, branches, logs, poles/piles, sawn wood, wood chips	High risk potential for importation on *Eucalyptus* logs	(NZMAF, 2003, USDA-FS, 2003, CABI-FC, 2008)
Phellinus spp. (incl. *P. rimosus, P. robustus, P. wahlbergii*)	Hymenochaetales: Hymeno-chaetaceae	AUS	Broad host range, incl. *Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Sarocladium oryzae	Hypocreales:	AS, AF, MEX, USA (LA), SAM (ARG, BRA, VEN), AUS	*Bambusa*	bamboo		(NZMAF, 2003, CABI-FC, 2008)
Fusarium circinatum	Hypocreales: Nectriaceae	USA, MEX, ZAF, CAR (HTI), AS (JPN)	*Pinus, Pseudotsuga*	bark, lumber, nursery stock, seeds, WPM		(AQIS, 2007)
Fusarium solani f. *dalbergiae*	Hypocreales: Nectriaceae	AS (IND) (native)	Hardwoods: *Dalbergia sissoo*	bark, stems, wood	*F. solani* is a serious pathogen and can cause 60-80% losses in *D. sissoo* stands	(FAO, 2007c, CABI-FC, 2008, ISSG, 2008)
Ceratocystis albifundus	Microascales: Ceratocystidaceae	ZAF (native)	Hardwoods, incl. *Acacia, Burkea, Combretum, Faurea, Ochna, Ozoroa, Protea, Terminalia*	bark, logs, roots, WPM	Serious wilt disease of introduced and native trees in South Africa - infects and kills trees of all ages	(FAO, 2007a, CABI-FC, 2008)
Ceratocystis fagacearum	Microascales: Ceratocystidaceae	USA: mid-West, Appalachians, TX (not other Gulf States)	*Castanea, Prunus, Quercus*	firewood, natural spread (with bark beetles)	Vectored by *Pseudopityophihorus* spp.; vectored by *Colopterus truncatus* - native to the Americas	(Rexrode and Brown, 1983, Aldrich *et al.*, 2003, USDA-FS, 2006a, Worrall, 2007, Juzwik *et al.*, 2008)
Ceratocystis eucalypti	Microascales: Ceratocystidiaceae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Ceratocystis moniliformis	Microascales: Ceratocystidiaceae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Ceratocystis moniliformopsis	Microascales: Ceratocystidiaceae	AUS	*Eucalyptus obliqua*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Leptographium lundbergii	Microascales: Ceratocystidiaceae	AUS	*Eucalyptus, Nothofagus cunninghamii*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Ophiostoma pluriannulatum	Ophiostomatales: Ophiostomataceae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)

Species	Order: Family	Distribution	Hosts	Pathways	Comments	References
Ophiostoma wageneri	Ophiostomatales: Ophiostomataceae	USA (southwest/west), CAN (west)	*Abies, Picea, Pinus, Pseudotsuga menzesii, Tsuga*	bark, insect vectors, lumber, WPM		(AQIS, 2007)
Setosphaeria rostrata	Pleosporales: Pleosporaceae	AS, AF, USA (FL, MS, TX), BRA	Polyphagous, incl. *Bambusa, Cocos nucifera, Eucalyptus tereticornis, Mangifera indica, Psidium guajava,* Poaceae	bamboo		(NZMAF, 2003, CABI-FC, 2008)
Ganoderma lucidum	Polyporales: Ganodermataceae	AUS, USA (FL, LA, MS), CAR (PRI, TTO)	Hardwoods & conifers: *Corymbia citriodora, Eucalyptus*; Pinaceae and many other tree hosts	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003, Farr *et al.*, 2006)
Perenniporia medulla-panis	Polyporales: Polyporaceae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Piptiporus australiensis	Polyporales: Polyporaceae	AUS	*Corymbia fastigata, Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Piptiporus potetntosus	Polyporales: Polyporaceae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Phytothphora ramorum	Pythiales: Pythiaceae	EUR (west and central), CAN, USA (CA, OR, WA)	50 plant species, incl. *Acer, Aesculus, Arbutus, Arcostaphylos, Camellia, Corylus, Hamamelis, Lithocarpus, Quercus, Rhododendron, Sambucus, Taxus, Vaccinium, Viburnum*	bark, conveyances (anything with soil), foliage, logs, potting media (with plants), stems, wood, WPM (with or without bark)	Destroying forests in 3 western U.S. states (CA, OR, WA)	(CABI-FC, 2008)
Heterobasidion annosum	Russulales: Bondarzewiaceae	USA, CAN, AS (IND, CHN), EUR	Hardwoods & conifers, incl. *Alnus, Betula, Crataegus; Abies, Cedrus, Juniperus, Larix, Pinus, Picea*	bark, insect vectors, lumber, WPM		(Farr *et al.*, 2006, AQIS, 2007)
Stereum hirsutum	Russulales: Stereaceae	AUS	*Eucalyptus*	logs	High risk potential for importation on *Eucalyptus* logs	(USDA-FS, 2003)
Uredo tectonae	Uredinales: Chaconiaceae	AS (native), MEX, CAM, USA (CA)	*Tectona grandis* (Lamiaceae)		Parasitic disease of teak -- may cause serious losses in nursery production	(Nair, 2007, Tkacz *et al.*, 2007)
Puccinia psidii	Uredinales: Pucciniaceae	CAM, SAM, CAR, USA (FL), THA	*Eucalyptus* and other Myrtaceae	bark, lumber, nursery stock, seeds, WPM		(AQIS, 2007)
Endocronartium harknessii	Urediniomycetes: Cronartiaceae	CAN, USA, MEX	*Pinus*	lumber, nursery stock, seeds, WPM		(AQIS, 2007)
Endocronartium pini	Urediniomycetes: Cronartiaceae	AS, EUR	*Pinus* (including *P. sylvestris*)	bark, poles/piles, sawn wood, wood chips	Mainly windborne but also vectored by insects (*e.g.*, genera include *Pissodes, Dioryctria, Laspeyresia, Lagria, Dioryctria*)	(NZMAF, 2003, CABI-FC, 2008)
Ustilago shiraiana	Ustilaginales: Ustilaginaceae	AS, EUR, USA (CA, FL, LA, MD, MS, TX)	*Bambusa, Nypa fruticans, Phyllostachys*	bamboo		(NZMAF, 2003, CABI-FC, 2008)
NEMATODES						
Bursaphelenchus xylophilus	Tylenchida: Aphelenchoididae	USA, CAN (native), AS (JPN, CHN, KOR, THA), EUR (POR)	Conifers, incl. *Abies, Larix, Picea, Pinus, Pseudotsuga menzesii*	bark, lumber, nursery stock, wood chips, WPM	Causal agent of pine wilt disease - has reached epidemic proportions in Japan; vectored by longhorned beetles in the genus *Monochamus*	(Magnusson *et al.*, 2001, NZMAF, 2003, AQIS, 2007, FAO, 2007b)

Country codes: ARG-Argentina; AUS-Australia; AUT-Austria; BGD-Bangladesh; BRB-Barbados; BEL-Belgium; BLZ-Belize; BMU-Bermuda; BRA-Brazil; BUR-Burma; CAN-Canada; CHL-Chile; CHN-China; CRI-Costa Rica; CUB-Cuba; CZE-Czech Republic; DEU-Germany; DMA-Dominica; DOM-Dominican Republic; ESP-Spain; EST-Estonia; FJI-Fiji; FIN-Finland; FRA-France; GBR-United Kingdom; GLP-Guadeloupe; GMB-Gambia; GRD-Grenada; GUY-Guyana; HND-Honduras; IND-India; IRN-Iran; IRQ-Iraq; ITA-Italy; JAM-Jamaica; JPN-Japan; KAZ-Kazakhstan; KEN-Kenya; KIR-Kiribati; KOR-Korea; LKA-Sri Lanka; LVA-Latvia; LTU-Lithuania; MAR-Morocco; MDG-Madagascar; MEX-Mexico; MMR-Myanmar; MTQ-Martinique; MUS-Mauritius; MYS-Malaysia; NCL-New Caledonia; NDL-Netherlands; NIC-Nicaragua; NPL-Nepal; NZL-New Zealand; PAN-Panama; PAK-Pakistan; PER-Peru; PHL-Philippines; PNG-Papua New Guinea; POL-Poland; PRI-Puerto Rico; PRT-Portugal; RUS-Russia; SAU-Saudi Arabia; SLB-Solomon Islands; SLV-El Salvador; THA-Thailand; TTO-Trinidad and Tobago; TUN-Tunisia; TUR-Turkey; TWN-Taiwan; TZA-Tanzania; UKR-Ukraine; URY-Uruguay; USA-United States; VEN-Venezuela; VIR-Virgin Islands (U.S.); VNM-Viet Nam; WAM-Samoa; ZAF-South Africa. ***U.S. States:*** AK-Alaska; AR-Arkansas; CA-California; CO-Colorado; CT-Connecticut; DE-Delaware; FL-Florida; GA-Georgia; IL-Illinois; IN-Indiana; KS-Kansas; LA-Louisiana; MA-Maine; MD-Maryland; ME-Maine; MI-Michigan; MO-Missouri; NC-North Carolina; NE-Nebraska; NH-New Hampshire; NJ-New Jersey; NY-New York; OH-Ohio; OK-Oklahoma; OR-Oregon; PA-Pennsylvania; SC-South Carolina; SD-South Dakota; TN-Tennessee; TX-Texas; VA-Virginia; WA-Washington; WI-Wisconsin; WV-West Virginia.

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